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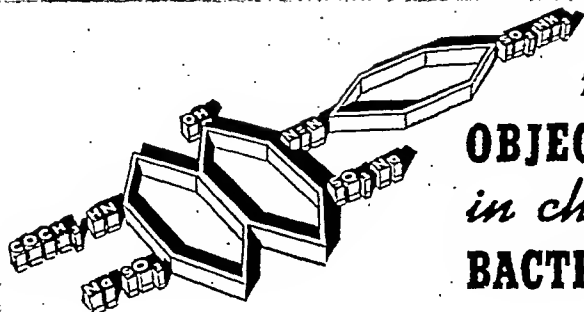
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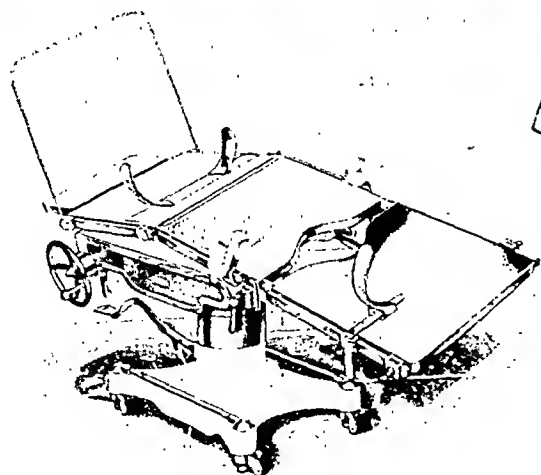
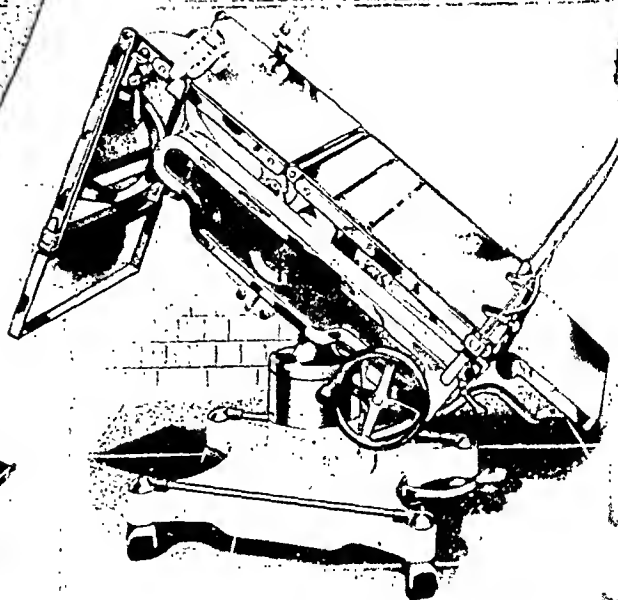
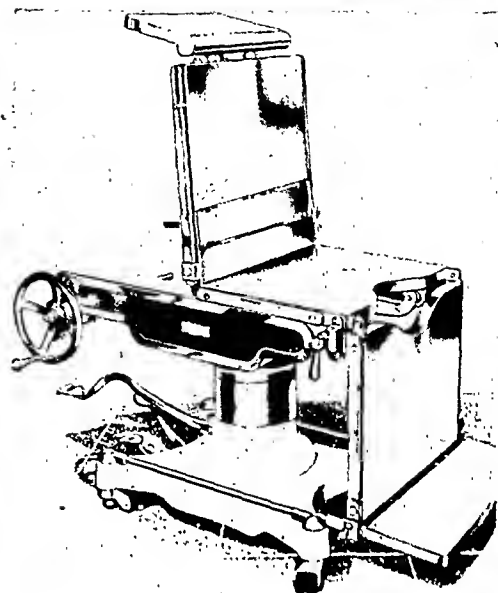
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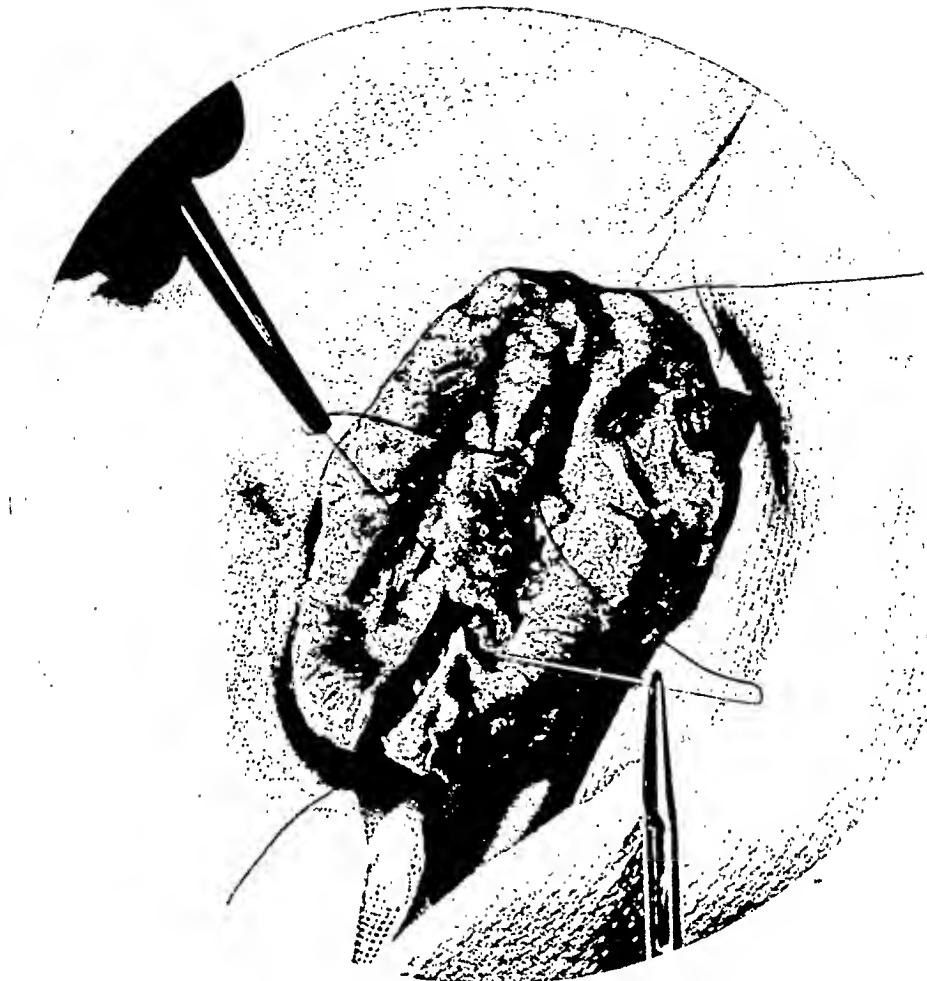
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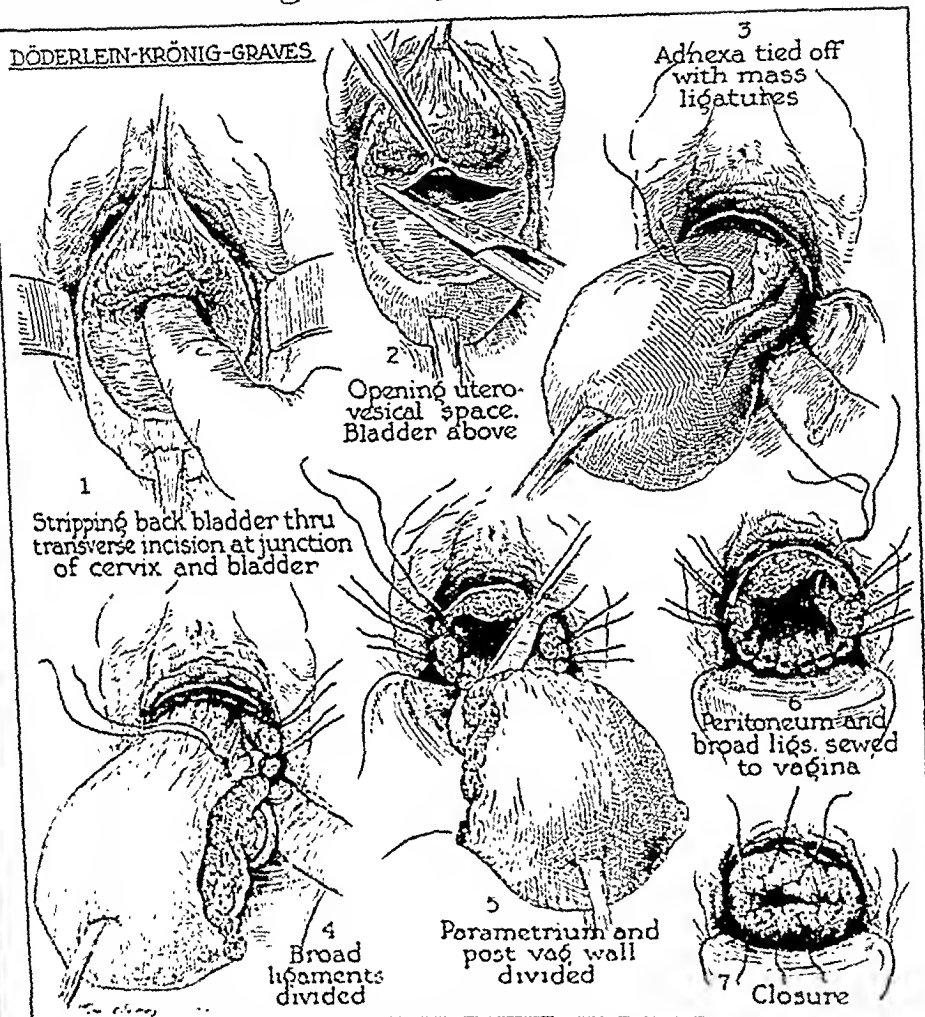
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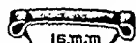
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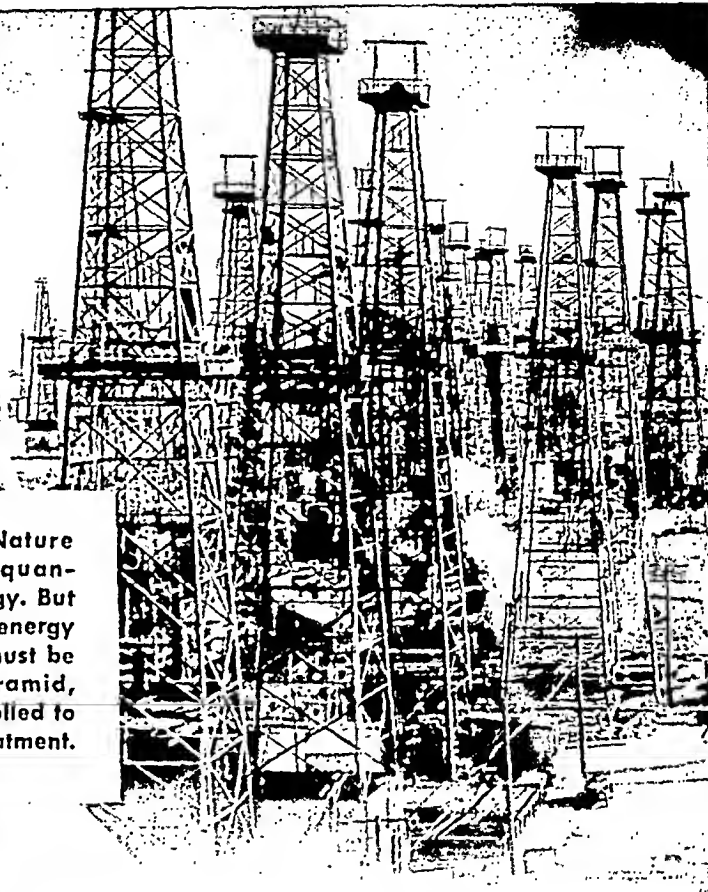
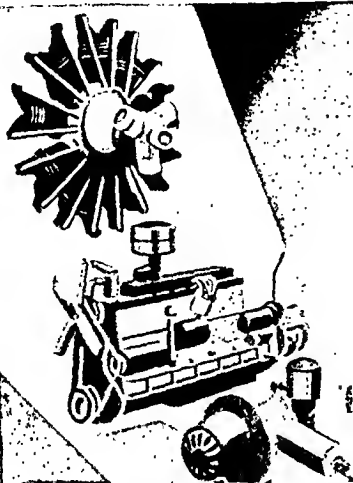
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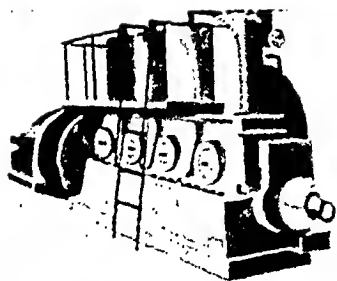
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Vol. 4

OCTOBER, 1938

No. 4

Original Communications

EXPERIMENTAL OBSERVATIONS ON THE SURGICAL TREATMENT OF HYPERTENSION*†

HARRY GOLDBLATT, M.D., C.M., CLEVELAND, OHIO

IN RECENT years surgical treatment of hypertension has come to the fore. This has consisted of denervation of some organs or section of nerves and excision of ganglia connected with the vasomotor apparatus of the abdomen. Denervation of the adrenals or kidneys, section of splanchnic nerves, section of anterior nerve roots, and excision of celiac or lumbar ganglia have been the operations of choice. Some of these procedures have been combined with unilateral or partial bilateral adrenalectomy. Irradiation of the adrenals by roentgen rays and partial adrenalectomy alone also have been tried. It is interesting to note that some of the methods which were regarded as effective at first were discarded later as useless even by the originators. It is also noteworthy that only the originators of each operation have been enthusiastic about the beneficial effects of their operation and have reported poor success or failure with other methods. As in the case of other methods of treatment, factors other than the level of the blood pressure, such as disappearance of headache, and other subjective symptoms have been used in the evaluation of the effect of the treatment. The unreliability of such criteria need not be stressed. It is a striking fact that no matter what the type of surgical operation on the nervous system, the percentage of cases in which a significant lowering of the blood pressure has been reported is about the same for all. After all the operations the percentage of cases in which there is a return of the blood pressure to normal is relatively small.

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†From an address delivered as part of a symposium at the second Louis A. Greenfelder Memorial Lectureship, Michael Reese Hospital, Chicago, Ill., Nov. 23, 1937.

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†From an address delivered as part of a symposium at the second Louis A. Greenfelder Memorial Lectureship, Michael Reese Hospital, Chicago, Ill., Nov. 22, 1937.

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the operation and of the restriction of activity which follows. An explanation of the remainder of the beneficial effect in some cases is suggested by the investigations that have been made on the effect of the same operations on experimental hypertension due to renal ischemia. Briefly, this type of hypertension* can be produced at will by constricting both main renal arteries by means of a special clamp or by constricting the main artery of one kidney and at the same time, or later, removing the other kidney. It also can be accomplished by constricting the aorta above both renal arteries. If the constriction of the main renal arteries is moderate, but adequate, the blood pressure remains elevated, and there is little or no accompanying disturbance of renal function, although the hypertension persists for years. After several years of hypertension, the small arteries and arterioles show some thickening of the media and sometimes slight hyalinization of the intima, especially in retinal arterioles. This type is similar to the benign phase of human essential hypertension. If the constriction of the renal arteries is made severe, there follows hypertension and reduced renal function which may lead to fatal uremia. The arterioles of many organs show severe changes, such as hyalinization, fibrinoid degeneration, and necrosis. This type resembles the acute malignant phase of human essential hypertension. It is upon experience with the treatment of these two types of experimental hypertension that the comments on the surgical treatment of human hypertension are based. All of the operations on the nervous system that have been performed on man have also been carried out on animals without any effect in preventing or permanently lowering this type of experimental hypertension. In the animals more extensive operations have also been carried out. Total sympathectomy of thorax and abdomen and even pithing have had no effect on this type of experimental hypertension. The effect on the vasomotor apparatus is presumably the same as in man. There is, however, one notable difference between the two. In the animals the restriction of blood to the kidneys is effected by constriction of the main renal arteries by means of a rigid clamp. This is not altered by any of the operations on the nervous system. In man, on the contrary, the counterpart of the effect of the silver clamp is produced by the constriction or thickening of the wall of the arterioles of the kidney. It is conceivable, at least, that some of these vessels are merely in spasm and still under the influence of the nervous system and that they are, therefore, in a reversible state and can become dilated as a result of removal of the vasoconstrictor effect. The conclusion that follows from these experiments is that what improvement does occur from these operations, in all probability is, apart from the

*For complete bibliography, see Goldblatt, Harry: *Experimental Hypertension Induced by Renal Ischemia*, Harvey Lectures, Baltimore, 1937-38, Williams and Wilkins, Vol. 32.

effect of enforced rest, due to the improvement of the circulation through the kidneys and not to any effect on the rest of the vasomotor apparatus of the abdomen.

As concerns interference with the adrenals, one can merely state that the experimental work up to the present time shows that removal of the medulla of both adrenals has no significant effect in preventing or lowering blood pressure. This decreases materially the probability that epinephrine plays any part in the phenomenon. It has been found that experimental hypertension due to renal ischemia is not prevented or lowered by partial adrenalectomy, unless the amount of the cortex left is inadequate to support life. There is, therefore, no experimental basis for any surgical or other physical interference with the adrenals in the treatment of hypertension. It seems fair, in the circumstances, to sound a note of warning about this method of treatment which is still being practiced by some surgeons.

One obvious surgical therapeutic procedure which suggests itself as the result of this work is the possible improvement of blood supply to the functioning components of the kidney by increasing the collateral circulation. In the animals with experimental hypertension induced by renal ischemia, whenever there is a return of the blood pressure to a lower level, it is due to inadequate initial clamping of the renal arteries or to the development of effective accessory circulation by way of ureteral and capsular vessels, which may become very prominent. If, before constricting the renal artery, the kidney is decapsulated and adipose tissue or muscle is attached to the denuded cortical surface, the accessory circulation from the adherent tissues becomes very prominent and interferes with the development of pronounced elevation of blood pressure. Since, in the animals, the constriction is only of the main renal artery, such accessory circulation can be of functional significance. The fact that animals have survived several years the complete closure of both main renal arteries, when effected gradually, by increasing the constriction at intervals, is proof that such accessory circulation can be functionally highly effective. However, in human essential hypertension, the vascular disease most frequently involves also the afferent pre-glomerular arterioles, so that collateral communication with the larger vessels would not improve circulation to glomeruli. Whether improvement of blood supply to some glomeruli, to tubules and interstitial tissue would occur as a result of renal decapsulation and attachment of omentum, muscle, or other tissues to the surface of the kidney, and whether it would be effective in lowering blood pressure in human essential hypertension cannot be determined without trying this type of operation. Although I have hesitated to recommend it, yet there is probably more justification on an experimental basis for making this test than there has been for some of the surgical procedures that have already been practiced. The cases in which the surgical production of

accessory circulation would be most effective would be those in which the hypertension is due to sclerosis of the main renal arteries alone or their very large branches. The difficulty of making a diagnosis of this condition is obvious, so that unless the method could be applied to essential hypertension associated with renal arteriolar sclerosis the procedure would be of greatly restricted value.

An interesting recent practical application of this work, which centers upon the renal origin of so-called essential hypertension, has been the finding in children and adults of hypertension associated with unilateral pyelonephritis and vascular disease, and the prompt return of the blood pressure to normal after excision of the diseased kidney. Until 1930, according to Bell and Pedersen, hypertension associated even with bilateral pyelonephritis had not been reported. Since then, Longcope and others have reported the occurrence of hypertension in some cases of bilateral pyelonephritis, and, from the meager studies of the kidneys, in these and in the cases of unilateral disease it has become probable that the hypertension associated with this condition in children and adults occurs only when there is associated vascular sclerosis or when the inflammatory disease produces the same effects on renal circulation as does vascular disease. In cases of unilateral arteriolar nephrosclerosis with hypertension, which have been reported by Moritz and Oldt, if the diagnosis could be made in life, removal of the diseased kidney might result in a return of the blood pressure to normal, as in the cases of unilateral pyelonephritis.* Unfortunately, unless the production of accessory circulation would be effective, nothing but transplantation of a normal kidney or kidneys, with the removal of both diseased kidneys, could be expected to relieve the hypertension associated with bilateral pyelonephritis or bilateral arteriolar sclerosis of the kidneys.

*From the James Buchanan Brady Urological Institute and Department of Medicine of Johns Hopkins Hospital, there have just been reported two cases of hypertension associated with unilateral renal vascular disease in which the removal of the diseased kidney resulted in a prompt return of the blood pressure to normal. A similar result has been obtained in a third unreported case (personal communication from Prof. Hugh Young).

SOME ASPECTS OF BLOOD PRESSURE REGULATION AND EXPERIMENTAL ARTERIAL HYPERTENSION*

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FOR many years physiologists have been occupied with the study of the mechanisms which regulate blood pressure. A precise and detailed knowledge of the physiologic regulation of endovascular pressure is the key, not only to the physiology of normal circulation, but perhaps also to the pathogenesis of chronic arterial hypertension.

It is known that the arterial pressure is largely controlled by the activity of the heart, the cardiac rate, the cardiac output, the circulating blood volume, and, mainly, by the peripheral vascular resistance, the vasomotor tone.

The arterial pressure is dependent upon factors which are essentially labile and variable. In spite of the numerous influences which, in an unbalanced physical system, would cause extreme variations in pressure, fluctuation of mean blood pressure under differing conditions is strikingly limited. It may be asked, therefore, what are the mechanisms which prevent such fluctuations and maintain and adjust the blood pressure in this precise and sensitive manner so as to control and regulate the circulation and nutrition of the cells, tissues, and organs of the body.

In recent years experimental investigations have demonstrated that the regulation of blood pressure is essentially and fundamentally an *automatic, proprioceptive reflex mechanism*. In fact, the endovascular pressure itself regulates automatically the cardiac output, the circulating blood volume, and the peripheral vascular resistance so well that the arterial pressure is maintained within or quickly restored to normal limits. This *homeostasis of the arterial pressure* is effected mainly by the intermediation of the pressoreceptor innervation of different arterial and venous vascular areas.

The early experiments of v. Cyon and Ludwig,¹ as well as the more recent researches of v. Anrep and Starling,² Ladon and myself^{3,4} and De Burgh Daly and Verney⁵ have shown that the cardioaortic vascular zone, especially the aortic arch, is provided with a pressoreceptive reflexogenic innervation (Fig. 1). When the endovascular pressure rises

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in the left heart or aortic arch, impulses ascend centripetally along the cardioaortic nerves, inducing reflex cardiac slowing, diminution of cardiac output, and peripheral vasodilatation. On the other hand, when this endovascular pressure falls, the same pressoreceptors induce reverse vasomotor and cardiac reactions, characterized by vasoconstriction, cardiac acceleration, and an increase of cardiac output. These reflexes tend to keep a balance between hypertension and hypotension and to maintain normal arterial pressure.

One knows further from the work of Cooper,⁷ Marey,⁸ Francois-Franck,⁹ and Hedon¹⁰ that variations of carotid-cephalic arterial pressure immediately produces cardiac and vasomotor reactions. Carotid-

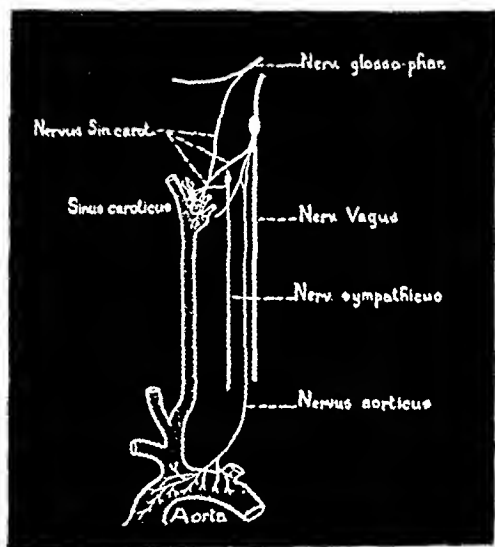


Fig. 1.—Diagram of the cardioaortic and carotid sinus pressosensitive innervation.

cephalic hypotension produced by clamping both carotid arteries induces acceleration of the heart, increase of cardiac output, and somatic vasoconstriction. The opposite phenomena, namely, cardiac slowing and somatic vasodilatation, are responses to carotid-cephalic hypertension. This mechanism of regulation of blood pressure was long attributed to the *direct* central influence of changes of blood pressure acting on the tonus of the cardiovascular centers.

The work of Czermaek¹¹ and Concato¹² and the observations of Sollmann and Brown¹³ showed, however, that the common carotid artery, particularly its bifurcation, may be the origin of cardiovascular reflexes elicited by mechanical manipulation, such as by compression of the neck in the region of the carotid bifurcation or by traction on the cephalic end of the carotid artery.

The experiments of Pagano¹⁴ and Siciliano¹⁵ in 1900 had already seriously damaged the concept of direct, central automatic regulation of blood pressure. But their experiments, which were incomplete and contradicted by Kaufmann,¹⁶ passed almost unnoticed, and the classical theory of the direct central regulation of blood pressure was still accepted until 1924 when new investigations, performed mainly in the laboratory of Hering^{17, 20} and in our laboratory,^{4, 5} clarified the forgotten observations of Pagano and Siciliano and revealed the existence



FIG. 2.—Diagram of carotid sinus in man.

of the carotid sinus mechanism by which the carotid blood pressure controls reflexly the general arterial pressure.

The term "carotid sinus" signifies a specially innervated area of the bifurcation of the common carotid artery (Figs. 1 and 2). Within this area are the origins of the internal and external carotid and the occipital arteries, the carotid bulb (which is a bulbous dilatation at the root of the internal carotid), and the carotid body or carotid ganglion which lies between the bifurcating arteries. This region is connected with the central nervous system by means of a distinct group of nerve fibers constituting the carotid sinus nerves. The nerve fibers originate in the ad-

ventitial coat of the arteries of the carotid bifurcation, mainly in the carotid bulb, and in the endothelial lining of the vessels of the carotid ganglion, as shown chiefly by De Castro¹⁸ and Nonidez.¹⁹

According to a technique (Fig. 3) developed in our laboratory, one or both carotid sinuses of a dog are isolated *in situ* from the circulation, taking care not to injure their innervation. Such isolated sinuses then are really segments of vessels with intact nerve supply and these segments may be perfused either by means of another dog or with a Dale-Schuster perfusing pump. In this manner the pressure within the lumen of this specialized and isolated segment of the vascular tree may be raised or lowered. Since this segment is connected to the animal only

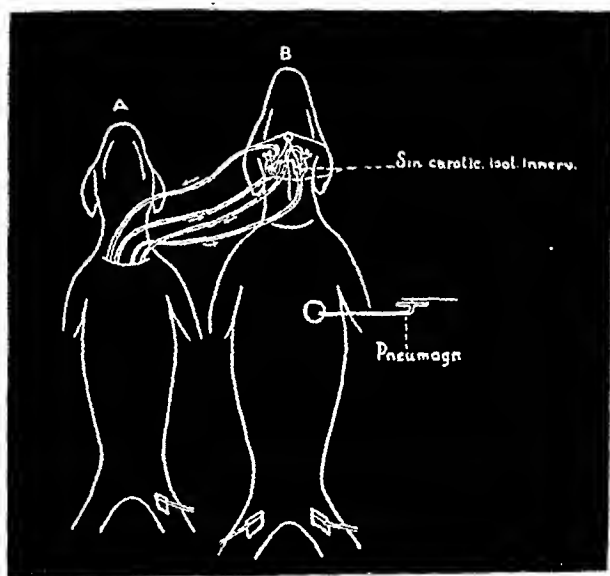


Fig. 3.—Technique of establishing isolated, innervated carotid sinuses in Dog B perfused by Dog A.

by intact nerves, it can be shown that it is only by reflexes originating within this area, due to differences in pressure, that the general blood pressure is regulated.

If the pressure inside the circulatory isolated but innervated carotid sinuses is increased, one observes (Fig. 4) that this rise of intracarotid sinus pressure is associated with a fall of the blood pressure in the general circulation of the dog. Together with the fall of arterial pressure, there is a slowing of the heart. Conversely, if the pressure is lowered in the isolated carotid sinus, the general blood pressure of the dog rises and the heart accelerates.

These experimental observations thus demonstrate that the general arterial blood pressure is automatically controlled by means of the endovascular pressure itself acting on the pressosensitive nerve endings of

the carotid sinuses. The pressosensitivity of the carotid sinus is very great; it has indeed been shown by Koch²⁰ and by my co-workers and myself² that, in the carotid sinns of the dog, an increase or a decrease of even 1 mm. mercury pressure from the normal arterial pressure is sufficient to produce reflex compensatory changes in the general blood pressure. Moreover, Bronk and Stella²¹ could register action potential variations from the carotid sinus pressoreceptors with each systolic-diastolic variation of carotid sinus pressure.

Let us analyze briefly the components of these proprioceptive mechanisms of blood pressure regulation by the aortic and especially the carotid sinus pressoreceptor reflexes.

The regulation of the heart rate depends mainly upon reflex changes in the vagus tone and to a slight degree upon changes in the sympathetic activity.

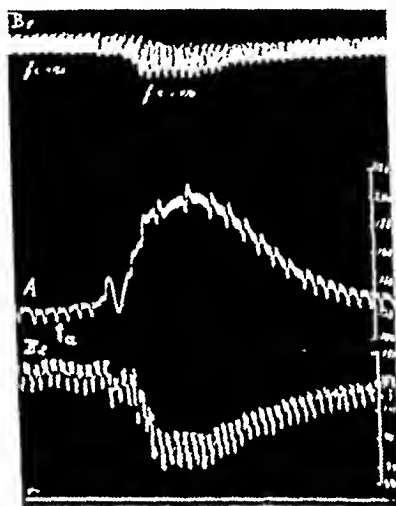


Fig. 4.—Dogs A and B prepared according to the technique shown in Fig. 3. Upper curve, heart rate of Dog B; middle curve, blood pressure of Dog A perfusing the carotid sinuses of Dog B; lower curve, femoral blood pressure of Dog B. At 4a: adrenalectomy hypertension in Dog A, and hence in the carotid sinuses of Dog B, induces heart slowing and hypotension in Dog B.

The control of the circulating blood volume and the peripheral vascular resistance is mainly due to reflex changes in the arterial and venous tone and also to the changes in the tone of the arteriovenous anastomoses.

Thus, we find that an increase of carotid sinus pressure produces reflex arterial and venous dilatation and a reduction in caliber of the arteriovenous anastomoses. A lowered carotid sinns pressure produces, on the other hand, a reflex arteriolar and venous constriction and an opening of the arteriovenous anastomoses.

By means of various experimental methods, it has been shown² that these vascular reactions occur, to a certain extent, in the peripheral

vessels, but take place mostly in the splanchnic area; that is to say, the mesenteric vessels, the spleen, liver, intestines, and kidneys.

Concerning the reflex regulation of the venous vascular tone by the carotid sinus pressoreceptive reflexes, the investigations of Fleisch²² and myself with Bouckaert, and Regniers²³ show that the mesenteric veins, isolated from general circulation but perfused in situ by means of Donegan's technique, contract reflexly in response to a lowering of carotid sinus pressure and dilate if the sinus pressure is increased. Thus, both the tone and the capacity of the abdominal venous reservoirs are controlled reflexly and automatically by the arterial blood pressure acting on the pressosensitive carotid sinus nerve endings.

The arteriolar and venous vascular tones are regulated not only by the carotid sinus and aortic reflexes by means of neurovascular influ-

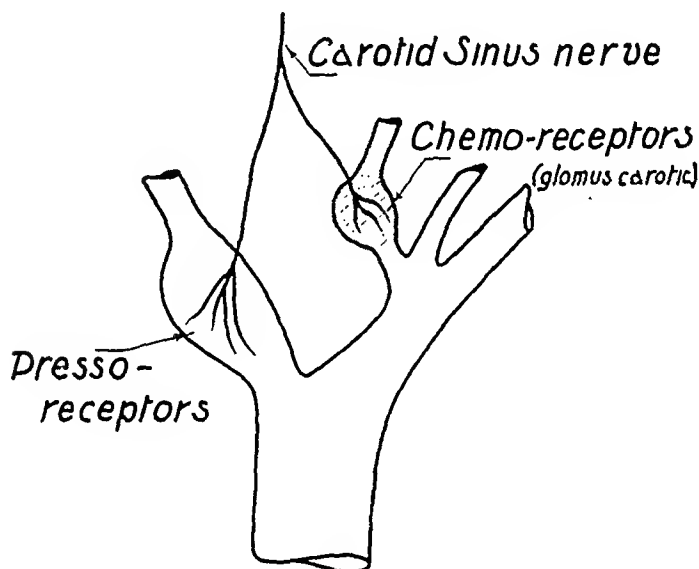


Fig. 5.—Diagram of the pressore- and chemoreceptors of carotid sinus.

ences, but also by reflex alterations in the adrenaline output. Our experiments^{4, 5} showed indeed that, when the pressure rises in the carotid sinus, the adrenaline discharge of the suprarenals is reflexly reduced; when the carotid sinus pressure is lowered, more adrenaline is liberated by the suprarenals.

Therefore, the arterial blood pressure, by acting on the pressoreceptors of the carotid sinus, provides one of the mechanisms for regulating the secretion and discharge of adrenaline, and thus further controls, in a humoral manner, the vascular tone, the heart rate, the circulatory blood volume, and probably also the caliber of the arteriovenous anastomoses.

I wish to point out that this suprarenal hormonal regulation of the circulation by the carotid sinus is only an accessory regulating mech-

anism. Indeed, experimental observations with Bouckaert and Nowak^{23, 24} have shown that the reflex neurovascular regulation of the blood pressure occurs quite well in the absence of the suprarenal medullary secretion. The increased discharge of adrenaline in response to lowered carotid sinus pressure is thus comparable to the increased release of adrenaline in response to emergencies, as demonstrated by Cannon.²⁵

Finally, another group of experiments has permitted us to assert that the carotid sinus zone, as well as the cardioaortic area, is provided with a reflexogenic innervation which is not only pressosensitive but also chemosensitive, so that changes in oxygen or carbon dioxide content in the blood and also the presence of several pharmacologic sub-

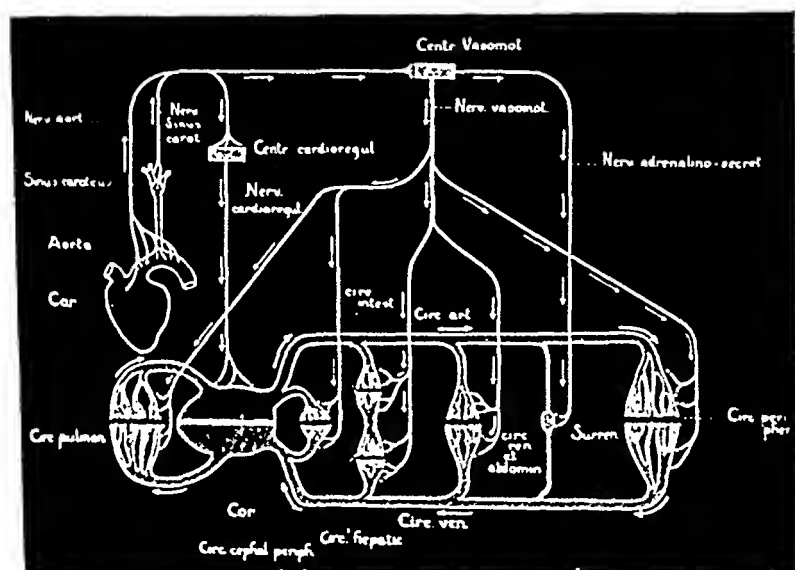


FIG. 6.—Diagram of the circulation and of the reflex neurovascular, neurocardiac, and adrenaline regulation of heart rate, vascular tone, and blood pressure by means of the cardioaortic and carotid sinus pressoreceptors and chemoreceptive mechanisms.

stances in the arterial blood can influence, by means of carotid sinus and aortic reflexes, the activity of the cardiovascular centers and thus modify the general blood pressure. These chemoreceptors of the carotid sinus are localized (Fig. 5) in the glomus caroticum, annexed to the carotid bifurcation, and are quite different from the pressoreceptors.

Fig. 6 shows schematically the afferent and efferent pathways of the proprioceptive mechanisms of cardiovascular regulation by means of the carotid sinus and cardioaortic pressoreceptors and chemosensitive areas.

Another question presents itself at this point: Are the cardioaortic and carotid sinus vascular zones the only regions provided with reflexogenic pressosensitivity and able to take part in the proprioceptive regulation of heart rate, vascular tone, and blood pressure?

Experimental observations by Bainbridge²⁶ and by McDowall²⁷ have shown that the right auricle, as well as the venae cavae at their entrance into the heart, are provided with receptors through which pressure changes in the venous system influence reflexly the heart rate and the arterial vascular tone.

More recently Schwiegek²⁸ showed that the branches of the pulmonary artery also are endowed with reflexogenic pressosensitivity regulating the heart rate and arterial vasomotor tone. Increase of pressure in the pulmonary arterial system causes reflex heart slowing and arterial vasodilatation, while lowering of pulmonary arterial pressure provokes the opposite cardiovascular reactions.

The centripetal pathways from these venoauricular and pulmonary arterial pressoreceptors are found in the cervical vagus nerves.

In 1929 we observed,⁴ however, that experimental suppression of the cardioaortic, carotid sinus, and cervical vagus nerves did not abolish completely the proprioceptive mechanism of cardiovascular regulation. Indeed, in a dog deprived of the pressosensitive reflexogenic innervation of the cardioaortic, carotid sinus, venoauricular, and pulmonary zones, the elevation of general arterial pressure still induced compensatory reactions characterized by vascular dilatation and diminution of adrenaline output. In the same animal arterial hypotension started the opposite compensatory reactions of vascular constriction and increased adrenaline secretion. This proprioceptive adaptation and control of vasomotor tone by the blood pressure is not of direct central origin. These reactions still persist in the "spinal" animal.

Experiments employing several different methods have permitted us, with the collaboration of Bouckaert, Farber, Hsu, and Wierzechowski,^{29, 30} to show that, in the dog deprived of carotid sinus, cardioaortic, pulmonary, and venous pressosensitive zones, as in the spinal animal, the proprioceptive regulation of vascular tone occurs through pressosensitive reflexes originating mostly from the vascular territory of the celiac and mesenteric arteries, and secondly from the territory of the thoracic arteries. These vasomotor reflex responses to blood pressure variations may arise in part from the mesenteric pressoreceptors located in the Pacinian mesenteric corpuscles, as shown by Gammon and Bronk,³¹ who recently registered centripetal action currents, related to blood pressure changes, from these organs.

These experiments raise another question: Are all vessels provided with reflexogenic pressosensitivity? There are experimental facts which make it possible to answer in the negative. Proprioceptive regulation of general vascular tonus is effected through reflexes, the pressoreceptors of which are situated only in certain well-localized vascular areas; namely, the carotid sinus, cardioaortic, venoauricular, pulmonary arterial, and thoracicosplanchnic zones.

Fig. 7 shows schematically the main functions of the pressosensitive reflexogenic vascular areas in the proprioceptive cardiovascular regulation.

After this review of the proprioceptive mechanisms of the regulation of general blood pressure, I propose to examine the significance of these mechanisms in the pathology of chronic arterial hypertension.

The cardioaortic and carotid sinus nerves not only are the means of the automatic pressoreceptive reflex regulation of general arterial pressure but also are the *buffer or moderator nerves* of the blood pressure.^{7, 17, 20} In fact, functional suppression of the aortic and carotid sinus nerves produces immediately an intense arterial hypertension; in dogs the pressure may rise from 130 to 250 to 300 as a consequence of the section of the aortic and carotid sinus nerves (Fig. 8 I). This marked increase of blood pressure is due to the release of vasoconstrictor and cardioaccelerator centers, the activity of which, under normal condi-

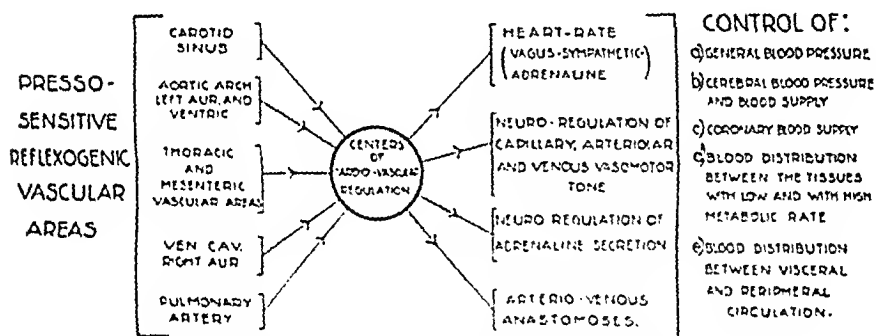


FIG. 7.—Diagram of the functions of the pressosensitive reflexogenic vascular areas in the proprioceptive cardiovascular regulation.

tions, is permanently moderated reflexly by the aortic and carotid sinus nerves. The moderator tone of these nerves is maintained and regulated by means of the pressure and the chemical constitution of the blood acting on the presso- and chemosensitive nerve endings of the cardioaortic and carotid sinus vascular areas.⁵

In dogs my co-workers and I^{1, 12} have observed arterial hypertension maintained at 250 to 300 for periods of nine to twenty-six months after section of the cardioaortic and carotid sinus moderator nerves (Fig. 9). The same observation has been made by Nowak²² on dogs up to three years after section of these moderator nerves. If, in a certain number of animals, section of the cardioaortic and carotid sinus nerves produces only a temporary hypertension, this is due to the presence of accessory fibers of the cardioaortic nerves in the vagus, or because in certain animals the pulmonary and mesenteric intestinal pressosensitive nerves may take over the moderator function of the cardioaortic and carotid sinus nerves.

The degree of hypertension which develops after section of the moderator nerves depends mainly upon the sympathetic vasopressor tonus. This tonus is an index of the state of activity in the cortical psychomotor, hypothalamic, and bulbar centers, as well as the result of a series of humoral and cellular factors among which are the blood supply to the sympathetic centers and the CO_2 and oxygen content of the blood.

With Baer, Brouha, and Bouckaert, I^{22, 24} could show, indeed, the role of the vasopressor sympathetics in the mechanism of experimental hypertension produced by exclusion of the moderator nerves.

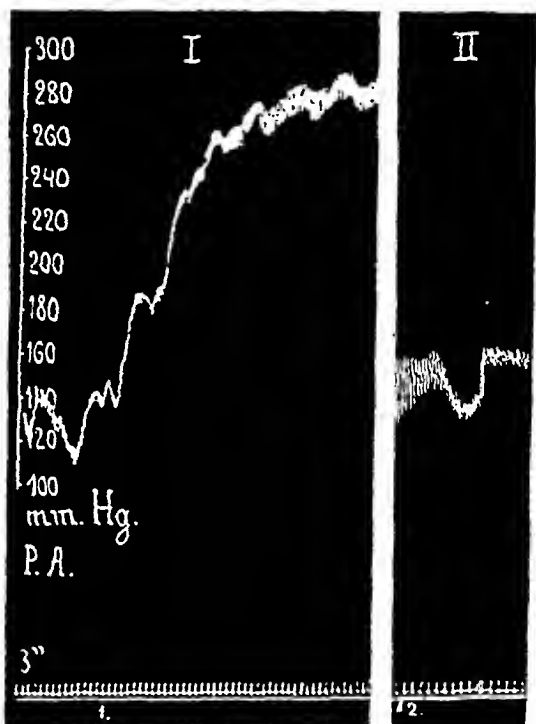


Fig. 8.—*I*, blood pressure of a normal dog; at 1, section of the four moderator nerves; hypertension. *II*, blood pressure of a totally sympathectomized dog; at 2, section of the four moderator nerves; no hypertension.

In dogs total excision of the sympathetic paravertebral ganglionic chains, from the stellate ganglia down to the pelvic ganglion, performed in three operative stages, prevents (Fig. 8 *II*) or causes the disappearance of this type of experimental hypertension. We noticed also that the pressoreceptive reflexes of cardioaortic and carotid sinus origin, regulating vascular tone and arterial pressure, are absent in the totally sympathectomized dog. No vasomotor response could be detected either by reflex or direct stimulation of the vasomotor centers in dogs up to several months and for as long as one year after total removal of the sympathetic chains. The general arterial pressure (Fig. 8 *II*), the ther-

moregulation, the psychic and motor behavior of these totally sympathetomized dogs were, however, normal as also shown by Samaan,³⁵ Bronha, Cannon, and Dill.³⁶ After each operative stage of the sympathetomy, the animal passes, of course, through a period of one or two weeks of general depression; the blood pressure is lowered as a consequence of the removal of an important part of the vasomotor tone of central origin. Soon, a progressive rise in peripheral vascular resistance is restored by means of a vasopressor mechanism, originating, in part, in the sympathetic synapses located more peripheral to the para-vertebral chains, and in the vascular wall. Thus the general blood pressure returns to normal levels. At complete rest, the blood pressure of the totally sympathetomized dog, however, may be somewhat under the mean level of normal dogs as a consequence of the slow rate of the heart deprived of its sympathetic innervation and controlled only by the vagal cardioinhibitory tone.

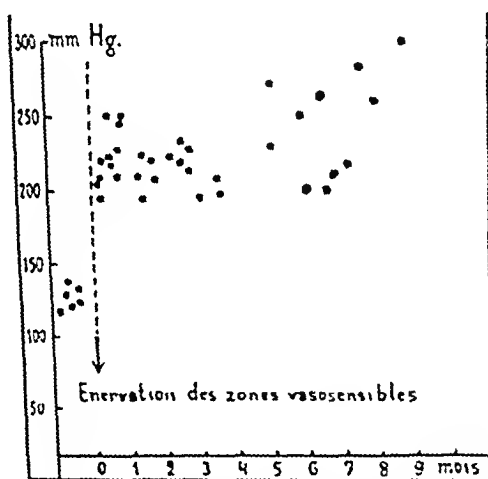


FIG. 2.—Blood pressure of six dogs before and after section of the four moderator nerves.

The question arises: Is the experimental hypertension induced by exclusion of the moderator nerves related to permanent clinical hypertension? We can, at least, answer a part of this question in the negative. This form of experimental hypertension varies from the typical nephropathic variety, but resembles more closely the so-called "essential neurogenic hypertension." This suggests that a functional deficiency of the moderator nerves, either in the region of the vasoconstrictor centers, in the region of the peripheral pressoreceptors, or in the region of the peripheral vasoconstrictor nerves, could be the underlying cause for essential hypertension and that surgical interruption of the efferent vasopressor sympathetic nerve paths might be indicated in this condition of "neurogenic" hypertension.

Recently, Allen and Adson³⁷ concluded from their clinical observations that bilateral resection of the splanchnic nerves, celiac ganglion, and two upper lumbar sympathetic ganglions, for essential hypertension, can be carried out without undue risk, that patients are not disabled as a result of this operation, and that the blood pressure of many of them is significantly reduced. Other patients note amelioration or relief of symptoms even when their blood pressures have not been significantly reduced.

A second method which will produce experimental hypertension was described by Dixon and Heller.³⁸ These authors injected a kaolin suspension into the cerebral ventricles or into the subarachnoid space. The mechanical compression, produced by the kaolin, led to cerebral anoxemia which particularly sensitizes the vasopressor centers to the stimulating action of CO_2 . That anemia and anoxemia may stimulate the vasopressor centers has been demonstrated by several experimenters. Raab³⁹ has shown, in the laboratory of Cannon, that central anemia, especially central acidosis, stimulates the vasopressor centers and increases their sensitivity to the humoral CO_2 . In our laboratory, Nowak and Samaan,⁴⁰ by perfusing the isolated head connected to the trunk only by the spinal vasomotor pathways, also produced evidence that acute anemia alone in the cerebral circulation provokes an intense somatic arterial hypertension. Experiments of Nowak⁴¹ further observed that the permanent decrease of cerebral blood supply by ligature of the carotid arteries, vertebral and spinal arteries may induce, in dogs, a condition of permanent arterial hypertension. These experimental observations support the views of Kylin⁴² and Raab,⁴³ who believe that some forms of clinical hypertension are related to some process of anoxic nature, such as endarteritis, localized in the region of the vasopressor centers.

Recently Goldblatt and co-workers⁴⁴ made a very important observation. They showed that, in the dog and in the monkey, renal ischemia by permanent incomplete compression of the renal arteries caused chronic, progressive arterial hypertension, with elevation of both the systolic and the diastolic pressures. This fact has largely been confirmed by Page⁴⁵ and others and in our laboratory by Elant,⁴⁶ Bouckaert, and myself.⁴⁷ In our experiments we obtained permanent hypertension in dogs reaching 245. Furthermore, we observed⁴⁷ that the carotid sinus vasopressor and hypertensive reflexes were especially active in such hypertensive dogs. Page⁴⁵ and Collins⁴⁸ observed that in dogs excision of the extrinsic renal nerves alone does not prevent experimental hypertension due to renal ischemia. The experiments of Goldblatt and his collaborators⁴⁹ showed that neither excision of one suprarenal body with denervation and destruction of the medulla of the other suprarenal, nor excision of the splanchnic nerves and the lower dorsal ganglia, which constitute an

important part of the sympathetic vasopressor system, prevents or cures experimental hypertension produced by renal ischemia.

More recently experiments performed by Bayless, Bonckaert, Elaut, and Samaan, and myself,⁵⁰ showed that complete excision of the whole sympathetic ganglionic chains in dogs also does not prevent the arterial hypertension following renal ischemia. The same observations have been made by Freeman and Page,⁵¹ and Alpert, Alving, and Grimson.⁵²

Our experiments^{47, 50} suggest that the arterial hypertension induced by renal ischemia may be due to an humoral factor which increases the excitability of the peripheral blood vessels to constrictor stimulations, mainly to the neurogenic vasoconstrictor influences; the same humoral factor inducing, on the other hand, a direct peripheral vasoconstriction and a disturbance in the physiologic mechanisms of the pressoreceptive reflex regulation of blood pressure. The sympathectomy up to the total removal of both ganglionic chains neither prevents nor cures this experi-

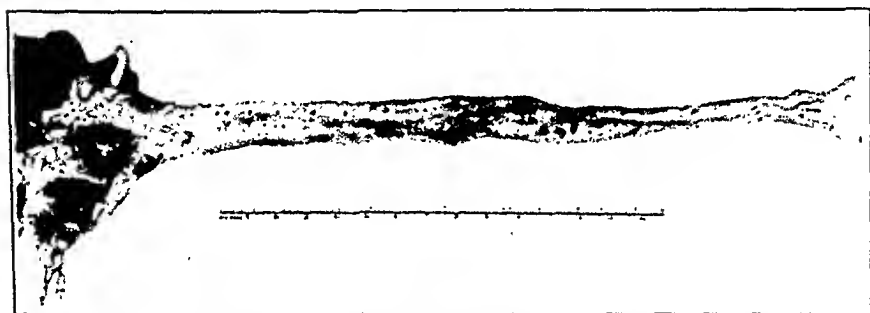


Fig. 10.—Lesions in the aorta of a thyroidectomized dog treated with large doses of vitamin D₂.

mental nephrogenic hypertension. But, as pointed out by Goldblatt, although the results of these investigations are in agreement with the conclusions of Prinzmetal and Wilson⁵³ and of Pickering⁵⁴ concerning the part played by the vasomotor system in human hypertension of nephropathic origin, yet they do not necessarily exclude some beneficial effects of operations on the vasomotor system or on the suprarenal glands in some cases of nephropathic hypertension. But we agree that further experimental and clinical studies are necessary to evaluate adequately the indications and the results of these surgical interventions.

A fourth method of producing experimental arterial hypertension is that indicated by Appelrot.⁵⁵ Further researches along this line were carried out by Handovsky⁵⁶ in this laboratory with the collaboration of Geormaghtigh,⁵⁷ of the Department of Pathology.

Their studies show that the repeated administration of relatively large doses of vitamin D₂ (calciferol) to dogs provoked a progressive augmentation of the arterial blood pressure. It was noticed also that the experimental dogs were very sensitive to the hypertensive action of adrenaline,

In the kidneys and elsewhere certain vascular lesions, mainly arteriolo-necrosis, developed which could be almost superimposed upon those found in human eclampsia, diphtheria, and scarlet fever. It is furthermore interesting to mention that vitamin D₂, which provokes arteriosclerosis in the rat and rabbit, does not induce the same vascular changes in the dog, unless one deprives this animal of its thyroid gland. Thus, in the thyroidectomized dog the administration of vitamin D₂ provokes arterial hypertension and with it intense and unusual vascular changes in the aorta and its major branches (Fig. 10), and typical lesions in the smaller arteries. We believe that these observations are interesting, since this form of experimental hypertension, characterized by high pressure and vascular lesions and sclerosis, resembles some types of human hypertension. As a matter of fact, many pathologists (Rössle,⁵⁷ Wegelin,⁵⁸ Behr,⁵⁹ Schmidtman⁶⁰) and clinicians have referred to a relationship between the thyroid gland, arteriosclerosis, and hypertension. The researches of Aub and his collaborators⁶¹ showed especially the close relationship between the thyroid and calcium metabolism.

These different groups of investigations, surveyed in this lecture show once more the bonds closely uniting experimental physiology, pathology, and surgery in attempts to elucidate the mechanisms regulating arterial blood pressure and the causes of hypertension. The knowledge thus gained, it is hoped, will lead to a more adequate treatment of this very important disease.

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ESSENTIAL HYPERTENSION: THE SELECTION OF CASES AND RESULTS OBTAINED BY SUBDIAPHRAGMATIC EXTENSIVE SYMPATHECTOMY*

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HYPERTENSION, or persistent elevation of the blood pressure, may produce progressively severe symptoms and in spite of all types of treatment it may terminate fatally. In addition to the medical measures used in treating the more serious types of hypertension, operations upon the sympathetic nervous system have been devised and carried out in a large number of cases; the mortality has been low and the results have been gratifying. However, at the Mayo Clinic we have been impressed with the importance of the selection of cases suitable for operation. Subdiaphragmatic extensive sympathectomy has been performed in 158 cases in the Section on Neurosurgery at the Mayo Clinic. There has not been an operative death and there were only five deaths after operation. Following the operation, the clinical improvement varied with the progress of the disease, the age of the patient, and the amount of vascular, cardiac, and renal damage. To determine the amount of potential physiologic response obtainable following sympathetic denervation, certain tests have been devised (Table I). These tests have prevented unsuccessful operations and have indicated in which cases a satisfactory lowering of the blood pressure or relief of clinical symptoms may be expected to occur after the operation.

TABLE I
PREOPERATIVE TESTS FOR HYPERTENSION

- | |
|---|
| 1. Effect of rest and sleep for 24 hours |
| 2. Effect of 3 gr. sodium amytal each hour for 3 doses |
| 3. Effect of $\frac{1}{2}$ gr. sodium nitrite each hour for 6 doses |
| 4. Effect of 5% pentothal sodium intravenously |

In essential hypertension there is increased peripheral arterial resistance, which is attributable to abnormal response of the arterioles to certain stimuli that produce marked fluctuation in blood pressure, emotion or cold increasing it greatly. There is some evidence that there are no abnormal vasomotor stimuli in essential hypertension; hence, it must be assumed that the arterioles react excessively to normal vasomotor stimuli.

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Postoperative observations have shown that, when the blood pressure fluctuates widely and reaches low levels at times, operation (that is, interruption of vasomotor impulses) is most beneficial, but, when the blood pressure is fixed at high levels, surgical treatment is ordinarily of little value. This emphasizes the necessity of preoperative tests to determine the flexibility of the blood pressure.

For convenience, essential hypertension has been divided into four clinical groups: Group 1 consists of cases in which there are mild sclerosis of the retinal arteries and a slight increase in blood pressure, which ordinarily becomes normal as a result of rest. In Group 2 have been placed cases in which there are moderate to severe hypertension, moderate sclerosis of the retinal arteries, and occasionally venous thrombosis and arteriosclerotic retinitis. Group 3 includes cases in which there is moderate to severe hypertension associated with a definite angiospastic retinitis. The severe and advanced types of the disease are included in Group 4; in the cases in this group there is very severe hypertension that is associated with an angiospastic retinitis and edema of the optic disks. This classification may be unsatisfactory because it fails to indicate the importance of the rapidity of progression. As a working basis, however, the classification is acceptable, since the seriousness of hypertension ordinarily increases progressively as the number of the group into which it is classified increases.

The medical treatment of mild essential hypertension is usually satisfactory but severe hypertension does not respond satisfactorily to medicine and diet. Some patients who have moderate hypertension Group 2 or 3 respond rather well to medical treatment; however, a non-toxic, adequate and prolonged vasodilator would solve the problem of the treatment in many cases. Unfortunately, no such substance is available. The nitrites, acetylcholine and acetyl-beta-methylcholine have in common a vasodilating action which is too short to be very valuable. Bismuth subnitrate, when administered orally, is of little value. There is some evidence that potassium thiocyanate may be effective (both before and after operation), but the dosage must be carefully regulated. The sedatives, particularly the barbiturates, are the most valuable drugs. The amount of sedative drug which should be given three or four times a day should be great enough to abolish nervousness and restlessness and small enough to avoid drowsiness and excessively slowed mental reactions. Many patients suffering from essential hypertension do not respond adequately to medical treatment. Surgical treatment is being advised only in these cases.

The purpose of surgical treatment of essential hypertension is to produce prolonged vasodilatation by interrupting the vasoconstrictor nerves to certain parts of the arterial system. Among the earliest operations employed were bilateral lumbar sympathetic ganglionectomy and cervicothoracic sympathetic ganglionectomy. These procedures were

not effective in lowering the blood pressure for a prolonged period because the operation was limited in its scope in that it did not denervate a sufficient vascular area. A more extensive operation consisting of intradural section of the ventral roots of the spinal nerves from the sixth thoracic segment to the second lumbar segment interrupts the sympathetic fibers which pass through these roots and which carry vasoconstrictor impulses. The entire vascular area below the diaphragm is thus denervated; this creates a reservoir which is unaffected when the undenervated vessels go into a spasm. Also, the suprarenal glands are denervated by interrupting the sympathetic fibers before they enter the capsules of the glands. This eliminates the central influence in producing excessive secretion of epinephrine under emotional stress. A thorough denervation of renal arteries and arterioles is performed. This increases the circulation of the kidneys and aids in the elimination of metabolic products which may play some role in the production of hypertension.

Following rhizotomy, the values for both the systolic and diastolic blood pressures of some patients remained lower than they were before the operation. This relieved the symptoms of hypertension. However, laminectomy and rhizotomy involved an unwarrantable surgical risk and the section of the splanchnic nerves alone proved inadequate in relieving hypertension. Therefore, the resection of all three splanchnic nerves, with a portion of the celiac ganglion, and removal of the upper lumbar ganglions on each side through a subdiaphragmatic approach was finally adopted (Fig. 1). In a rather large series of cases resection of one-third to one-half of each suprarenal gland was done, but this procedure has been discontinued; however, the glands are palpated for the presence of a tumor. The operation is divided into two stages and an interval of ten days is allowed to elapse between the operations on the right and the left sides respectively. From our studies, the subdiaphragmatic extensive sympathectomy is larger in scope and interrupts more thoroughly the efferent fibers from the thoracolumbar sympathetic outflow than does the supradiaphragmatic operation.

The futility of carrying out extensive sympathectomy in cases of hypertension in which there is irreparable damage to the cardiovascular mechanism is apparent. The operation should not be considered in a case in which there is mild and slowly progressive disease that is amenable to medical treatment. Operation seems most efficacious in the definite vasospastic type of hypertension in which sharp and brisk rises in blood pressure occur when the hands are immersed in cold water and in cases in which a marked fall in blood pressure is produced when pentothal sodium, sodium amytal, or a nitrite is administered. As an average rule, the patient must be under 50 years of age and the hypertension must be classed as of Group 2 or 3.

The so-called cold test is carried out by determining the blood pressure while the patient is resting and by continuing the determination until the value for the blood pressure reaches a basal level. A hand is then immersed, to the wrist, in water at 4° C. for one minute, and the blood pressure is determined at the end of thirty seconds and of one minute

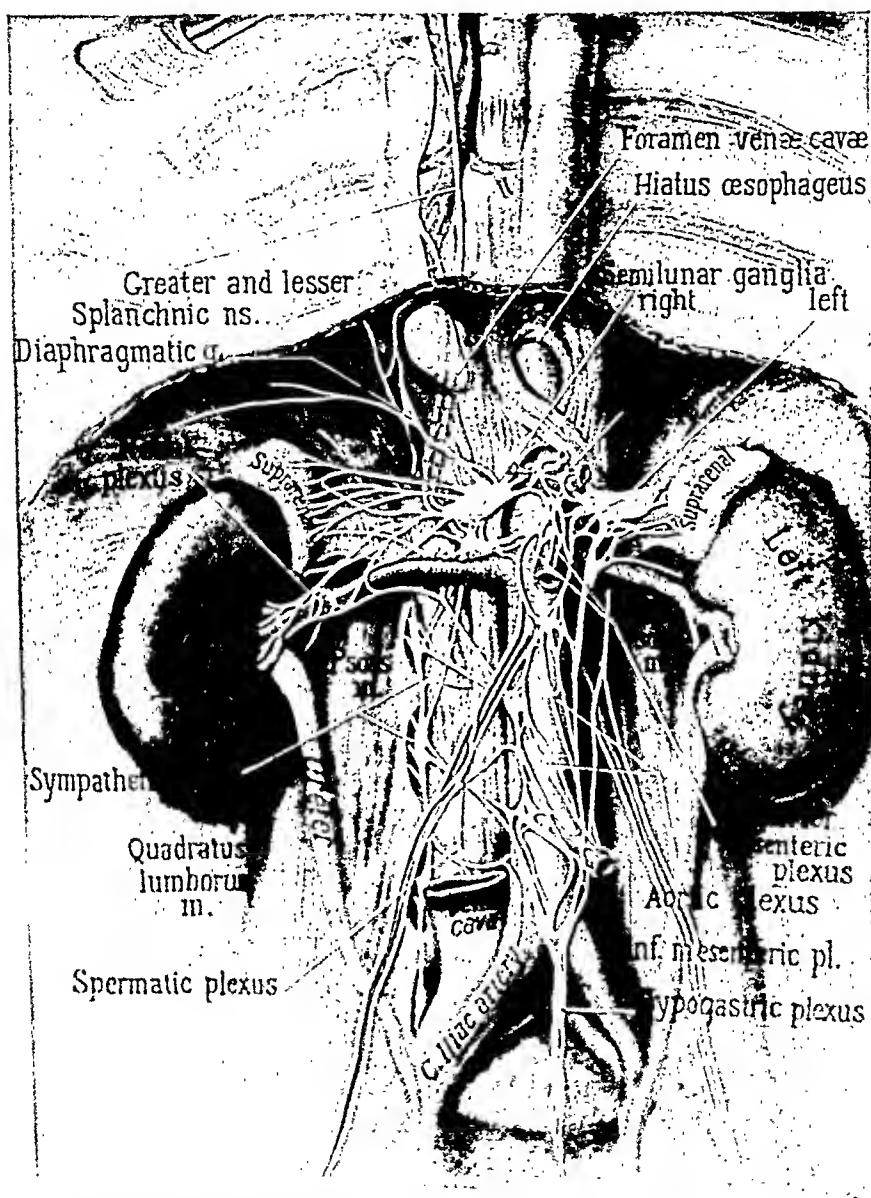


Fig. 1. Anterior representation of the major, minor, and lesser splanchnic nerves, upper lumbar sympathetic ganglions, and interruption of the sympathetic plexus in subdiaphragmatic extensive sympathectomy (From Lybat: *Regional Anesthesia*, W. B. Saunders Company).

thereafter. The highest value is considered characteristic of the response. The response of the blood pressure to this test is a measure of the way in which it responds on innumerable occasions to such stimuli as anxiety, fright, and mental stress and strain. In cases in which operation has produced a significant decrease in blood pressure, the systolic blood pressure responds less sharply to the test than does the diastolic pressure.

The following standard tests have been adopted and operation is advised only for patients whose blood pressure responds satisfactorily preoperatively: (1) slow and intermittent intravenous injection of a 5 per cent solution of pentothal until there is no further drop in the blood pressure; ordinarily 500 mg. to 1 gm. of the drug is injected; (2) administration of 3 gr. (0.2 gm.) of sodium amytal each hour for three successive hours; (3) administration of $\frac{1}{2}$ gr. (0.032 gm.) of sodium nitrite at intervals of thirty minutes until six doses have been given, and (4) hourly determination of blood pressure during rest and sleep for a minimum of twenty-four consecutive hours.

If the blood pressure decreases to normal or to nearly normal as a result of all these measures, the patient may be considered a satisfactory candidate for operation. If the response of the blood pressure to these measures is inadequate, the effect of operation is almost certain to be unsatisfactory. Unfortunately, even when these tests indicate that results of operation should be satisfactory, the actual results obtained will not necessarily be as good as the tests indicate. In other words, in spite of satisfactory response of the blood pressure to tests before operation it is possible that the blood pressure will not be reduced significantly by operation. At the clinic, we have made it a practice to perform the operation only in cases in which hypertension has been progressive in spite of medical supervision. However, we wish to emphasize that in almost every case of essential hypertension there is a period during which operation may be a valuable therapeutic procedure and one during which operation will almost certainly be valueless. Hence, if patients who have essential hypertension are to be operated upon, operation must be performed before the blood pressure becomes relatively fixed at high levels.

Contraindications for operation are as follows: An age of more than 50 years, congestive heart failure, angina pectoris, marked renal insufficiency, and advanced arteriosclerosis. Spasm and apparent sclerosis of the retinal arteries, retinitis, moderate enlargement of the heart, inversion of T-waves in the electrocardiogram, albuminuria, slight reduction in renal function, and a cerebrovascular accident from which recovery has been satisfactory are not in themselves considered contraindications to operation.

In carrying out extensive sympathectomy, the incision employed and the position of the patient on the operating table are similar to those employed for exploration of the kidney, except that the upper portion of the incision is extended high enough to include the oblique fibers of the latissimus dorsi muscle which will expose the twelfth rib. The incision is extended downward and outward over Petit's triangle, in order to expose the capsule of the perinephritic fat. Periosteal resection of the twelfth rib is then done; care is taken not to injure the pleura. The subcostal ligament of the twelfth rib is then incised; this allows upward retraction of the intercostal vessels and nerves and affords adequate exposure of the splanchnic nerves and lumbar ganglions. The liver is displaced forward and downward, as well as the capsule of perinephritic

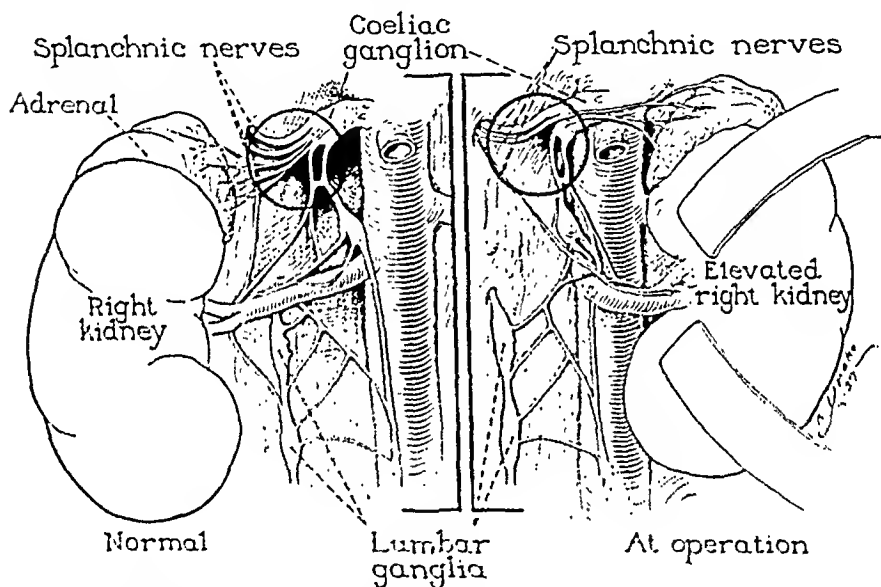


Fig. 2.—Diagrammatic representation of subdiaphragmatic sympathectomy, showing the normal relation of the ganglions and trunk (the kidney has been retracted).

fat. At this point a laparotomy sponge that has been moistened in physiologic saline solution is inserted to protect the peritoneum and its contents, which are being dissected from the underlying muscles. Gentle dissection with moist cotton-ball sponges reveals first a splanchnic trunk which is composed of major, minor, and lesser splanchnic nerves, which are descending from above downward between the two crura of the diaphragm. They are about 2 cm. in length and end in the coeliac ganglions. The resection includes the greater portion of the ganglion and the splanchnic nerves. The first and second lumbar sympathetic ganglions are exposed along the mesial border of the psoas muscle, and they are removed with the intervening trunk in order to interrupt fibers that pass downward in the lower end of the sympathetic trunk as well

as to interrupt white rami carrying efferent impulses to the upper two sympathetic lumbar ganglions. In this manner the splanchnic vessels, the suprarenal glands, and the kidneys are denervated (Fig. 2). The muscular fascial planes are approximated with continuous and interrupted sutures of chromic catgut and the skin is closed with silk sutures.

Following splanchnic resection and removal of the lumbar ganglions, the sweating function of the feet and lower part of the legs is lost. The cutaneous temperature is definitely increased and continues to remain so permanently. There is paralysis of the ejaculatory powers and of the muscles of the urogenital trigon that is similar to that which follows neurectomy of the presacral nerves. The menstrual cycle is not altered; moreover, the reproductive functions of the female are not changed. However, sterility of the male does result, although potentia and libido fortunately are not disturbed. Although this extensive sympathectomy deprives the small and large intestine, the ureters, and the bladder of the sympathetic innervation, it does not appear to increase the frequency or urgency of micturition or of defecation. Curiously enough, the atonic intestine, the dilated colon which so frequently troubles constipated people, and Hirschsprung's disease are definitely improved by this operation, since section of the sympathetic fibers to the intestine results in decrease of the inhibitory stimuli. The same applies to the muscular mechanism of the ureters and bladder.

Two definite phenomena in the cardiovascular mechanism develop following this operation. The first is a fall in blood pressure which occurs when patients first get out of bed and stand in the erect position. The second is the development of tachycardia. The first can be relieved with a tight binder and the second can be overcome by a decrease in exertion.

The effect of operation on symptoms, while variable, is roughly proportional to the effect on the blood pressure. However, patients not infrequently note relief of headache, fatigue, pain in the thorax, "dizziness," and nervousness, in spite of the fact that the blood pressure has not been greatly reduced by operation. It is probable that some of the symptoms associated with hypertension, such as headache, may occur only when the value for the blood pressure reaches an excessively high level. Operation which may reduce blood pressure only slightly may lower it sufficiently to prevent the occurrence of some of the symptoms. In most instances in which the blood pressure has been greatly reduced by operation, headache is relieved, pain in the thorax disappears, fatigue is lessened, and the patients gain weight and generally feel greatly improved. Many of them note diminution of nervousness and of a "let down" feeling, which gratifies them. Some patients have said that they feel "entirely well" or "better than in several years." In general, about 70 per cent of the entire group of patients were benefited clinically.

Some patients whose blood pressure has been greatly reduced by operation continue to note undue fatigue, weakness, and dyspnea for weeks or months after operation. One patient whose condition was followed closely did not regain normal strength until about six months after operation. We have not been able to determine definitely that the patients who noticed these symptoms following operation are those who continue to have orthostatic hypotension, but it appears that this is so.

SUMMARY

The surgical treatment of hypertension, which consists of subdiaphragmatic resection of the major, minor, and lesser splanchnic nerves, celiac ganglion, and lumbar sympathetic ganglions, is associated with a small risk and is followed by satisfactory alleviation of symptoms in selected cases.

Assuming that all hypertension can be divided into four groups, depending upon the severity, Group 1 does not require surgical treatment and Group 4 is too severe and too far advanced to warrant the expectation of adequate results. Groups 2 and 3 then should be considered for operative treatment. More important than the group are the pre-operative tests which indicate the potential physiologic changes that will follow sympathetic denervation of the vascular area below the diaphragm.

The so-called cold test indicates the upper limits of the blood pressure resulting from emotion or cold. The four other tests indicate the lower limits of the blood pressure readings associated with prolonged vasodilatation, and, therefore, denote the probable values for the blood pressure following extensive sympathectomy. They are as follows: (1) Twenty-four consecutive hourly determinations of the blood pressure are made while the patient is in bed, to establish the maximal blood pressure, the minimal blood pressure, and the mean or average blood pressure. (2) Slow and intermittent intravenous injection of a 5 per cent solution of pentothal sodium is made until there is no further drop in blood pressure. (3) One-half grain (0.032 gm.) of sodium nitrite is administered at intervals of thirty minutes until six doses have been given. (4) Hourly determinations of blood pressure are made during rest and sleep for a minimum of twenty-four hours.

If the blood pressure drops to nearly normal and if the patient is less than 50 years of age, the operation should be considered.

The results in a large series of cases have been quite satisfactory. The effect of the operation is physiologic in character, and, if so considered, the results justify the procedure.

BLOOD POTASSIUM DURING EXPERIMENTAL SHOCK*

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IN MAMMALS the extracellular body fluids contain from 13 to 25 mg. potassium per 100 c.c. and in individuals under basal conditions the level in the plasma remains remarkably constant, although the basic levels for individuals of the same species may differ as much as 20 per cent. It is well known that living cells, both plant and animal, contain from seven to twenty-five times as much potassium as their surrounding media.

With manifold K differences outside and inside the cell, it seemed reasonable to postulate that experimental procedures resulting in extensive tissue destruction, trauma, or injury causing increased cell permeability should result in increased extracellular potassium. Increases in the blood would only be expected to occur if the K was released from the cells too rapidly for the potassium regulating mechanism to handle. If the extracellular body fluids are depleted, their replacement by highly potassium cellular fluids should also result in a potassium rise.

It should be noted that even with the injections of potassium salts the plasma K level cannot be altered for long in normal animals (Zwemer and Truszkowski, 1937; Truszkowski and Zwemer, 1938), and that prolonged hyperpotassemia can only be produced by repeated injections. Marked elevations are injurious to the body regardless of whether the rise is a result of potassium injected, ingested, or released from the animal's own cells (Webster and Brennan, 1927). In the present paper we have followed the blood potassium levels after extensive cell injury or fluid depletion through shock to death.

EXPERIMENTAL PROCEDURES

Cats were used in the experiments and unless otherwise noted peripheral ear blood samples were taken for whole blood potassium analysis by the method of Truszkowski and Zwemer (1937). The red blood cells of the cat have a low potassium content and whole blood of this species is therefore a valid indicator of K changes. Parallel serum values are given in the hemorrhage experiments, in which extensive

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blood sampling would not complicate the picture. Ether anesthesia was used during the period of operative and traumatic procedures in the acute experiments, with the exception of the cases in which sodium amytal was used. Blood density was determined by the method of Barbour and Hamilton (1926). A condition of primary shock was produced within a few hours by hemorrhage, crushing of limbs, or manipulation of viscera. Slower development of the secondary shock syndrome occurred after intestinal obstruction, enterostomy, and pancreatitis.

RESULTS

Our impression based on thousands of potassium determinations in a number of animal species and man is that plasma potassium is remarkably constant and difficult to alter for long. The relative constancy of plasma potassium is shown in an animal in which only a small amount of tissue was damaged with no production of pain. The blood potassium was followed for a period of days, with frequent samples taken on the first day (Protocol 1).

Analysis of blood samples from an animal which remained under amytal anesthesia for thirty hours during which time eight samples of blood were taken (Protocol 2) showed no change in potassium. Under amytal the variations were less than 2 mg. per cent in either direction from the initial value. Initially and when the animal recovered, the values were somewhat higher.

In the hemorrhage experiments the values also varied little until the amount of blood removed was a large proportion of the initial estimated total.

Although one might expect that crushing of muscle and hemorrhage would be the procedures most likely to raise the plasma potassium content from endogenous sources, these animals showed K rises terminally only. This agrees with Stewart (1936) who found no plasma K rise with hemorrhage, but a marked K diuresis. He did not bleed his dogs to death. Kerr (1926) and Thaler (1935) report plasma K increase after hemorrhage. It was easier to produce shock by visceral manipulation than by trauma to the extremities and concomitantly the viscera lose their K content much more easily.

The results in individual animals are illustrated by complete protocols of the effects of fatal hemorrhage, limb trauma, and visceral manipulation as listed in Table 1. Some were graphed, with information supplementary to the K determination.

Table II gives data from sixteen animals in which a condition of secondary shock occurred. The initial blood potassium, the blood potassium during shock, and the interval between these two determina-

tions are given. The number of blood samples analyzed for their potassium content and the procedure initiating the shock syndrome are given also.

In animals acutely shocked with potassium salts, the blood K rises and the onset of symptoms are abrupt as in the present acute experiments (Table I); whereas, with the prolonged moderately elevated rises obtained with repeated injections (Truszkowski and Zwemer, 1938), the symptoms resemble those of the second group of cases (Table II).

The source of the blood sample is important, as it has been found in other experiments (Zwemer and Pike, 1938) that venous bloods coming from different organs may vary markedly in their potassium content. This finding and more specific studies of nerve excitation and of anesthetics on potassium changes in shock will be dealt with elsewhere.

In the foregoing experiments the blood was not taken from vessels draining the part of injury nor the region of operative procedure. Peripheral capillary blood resembles arterial blood in so far as potassium content is concerned; therefore the increases shown may in these cases be considered as holding good for arterial blood in general.

The data here presented agree with the postulate that potassium increases may be expected after severe tissue damage or extracellular fluid depletion, but that in a normal healthy animal it is difficult to disturb the potassium regulating mechanism.

DISCUSSION

In explanation of shock there have been many theories, each supported by extensive experimental work. For a review we refer the reader to papers by Cannon (1923), by Blalock (1936), by Meek (1936), and by Henderson (1938).

Diminished blood volume has been considered particularly important. The diminished effective blood volume might be due to fluid and electrolyte loss from the body as a whole, to capillary stasis and trapping of large amounts of blood in splanchnic or the traumatized area vascular

TABLE I
LIST OF PROTOCOLS

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- | | |
|-----|--|
| 1. | No. 3701.—Mild trauma, no shock, no K change |
| 2. | No. 3643.—Prolonged sodium amytal narcosis |
| 3. | No. 3701.—Arterial blood loss |
| 4. | No. 3707.—Repeated withdrawal of heart blood |
| 5. | No. 3752.—Repeated withdrawal of heart blood |
| 6. | No. 3755.—Repeated withdrawal of heart blood |
| 7. | No. 3641.—Mild trauma under sodium amytal anesthesia |
| 8. | No. 3644.—Trauma under amytal |
| 9. | No. 3640.—Severe trauma under amytal |
| 10. | No. 3650.—Severe trauma under ether |
| 11. | No. 3702.—Manipulation of viscera under ether |
| 12. | No. 3706.—Manipulation of viscera under ether with adrenals tied off |
-

TABLE I (CONT'D)
PERIPHERAL WHOLE BLOOD K OF THE CAT MAY REMAIN QUITE CONSTANT
NERVE BLOCKED AND TESTES CRUSHED UNDER ETHER ANESTHESIA (NO SHOCK)

| Cat 3701 | |
|---------------|----------------|
| Jan. 11, 1937 | 26.3 mg. % K |
| 12:30 P.M. | Operation |
| 1:45 P.M. | 27.5 mg. % K |
| 1:55 P.M. | 25.6 mg. % K |
| 2:00 P.M. | 26.3 mg. % K |
| 3:00 P.M. | 25.0 mg. % K |
| 4:00 P.M. | 25.8 mg. % K |
| 5:00 P.M. | 24.8 mg. % K |
| 8:20 P.M. | Testes swollen |
| Jan. 13, 1937 | 29.2 mg. % K |
| Jan. 16, 1937 | 26.4 mg. % K |
| Jan. 19, 1937 | 24.4 mg. % K |
| Jan. 21, 1937 | 23.8 mg. % K |

EFFECTS OF PROLONGED SODIUM AMYTAL NARCOSIS
Control Cat 3643, Weight, 2.6194 Kg.
Sex: female

| TIME | RELATIVE TIME | AMOUNT OF AMYTAL ADMINISTERED | CAPILLARY BLOOD K AS MG. % | REMARKS |
|--------------------------------|----------------|-------------------------------|----------------------------|--|
| Oct. 22, 1936 A.M. 10:50 | 0 | - | 33.2 | Healthy, adult cat not fasting |
| 10:51 | | | | |
| 11:05 | 15 min. | 2.6 ml. | | |
| 11:15 | 25 min. | 0.4 ml. | | |
| 11:25 | 35 min. | 0.5 ml. | | |
| 11:30 | | | | |
| 11:42 | 40 min. | | 27.2 | Heart rate 210; res- pirations, 42; tem- perature, 100.4 |
| | 52 min. | | 29.0 | |
| P.M. 1:47 | | | | Heart rate, 170; res- pirations, 33; tem- perature, 99.2; still unconscious; moves around a little |
| 2:00 | 2 hr. 57 min. | | | |
| 2:45 | 3 hr. 55 min. | 2.5 ml. | 27.1 | |
| 4:15 | 5 hr. 25 min. | | 25.6 25.6 | |
| Oct. 23, 1936 P.M. 4:00 | 29 hr. 10 min. | | | Has been in coma since morning; pec- uliar trembling con- dition |
| | | | 27.3 | |
| Oct. 24, 1936 A.M. 9:30 | 46 hr. 40 min. | | | Unable to move; fibrillar twitchings; drank some water after taking blood sample |
| | | | 30.0 | Recovered |

TABLE I (CONT'D)
EFFECTS OF ARTERIAL BLOOD LOSS

Cat 3701. Weight 3.94 Kg.

Sex: Male

Feb. 15, 1937

| TIME | RELATIVE TIME | AMOUNT REMOVED | WHOLE BLOOD K MG. %. | SERUM POTAS- SIUM MG. % | SERUM CA MG. % | SPECIFIC GRAVITY WHOLE BLOOD | SERUM SP. GR. | SERUM PROTEIN GM. % | |
|---------------|--|----------------|-------------------------------|----------------------------------|----------------------|---------------------------------------|------------------|---------------------------|------|
| A.M. | Under light ether anesthesia femoral artery exposed for bleeding | | | | | | | | |
| 11:20 | 0 | 10 c.c. | — | 15.4 | 12.9 | 1.0518 | 1.0292 | 7.62 | |
| 11:35 | 15 min. | 10 c.c. | 21.7 | 16.0} | 12.6 | 1.0518 | 1.0289 | 7.52 | |
| 11:45 | 25 min. | 10 c.c. | 23.0 | 15.3} | | 1.0494 | 1.0283 | 7.3 | |
| 11:55 | 35 min. | 10 c.c. | 21.9 | 14.4 | 11.9 | 1.0486 | 1.0278 | 7.13 | |
| P.M. | | | | | | | | | |
| 12:07 | 47 min. | 10 c.c. | 22.7 | 15.1 | 11.4 | — | 1.0273 | 6.96 | |
| 12:20 | 1 hr. | 10 c.c. | 21.3 | 13.9 | 11.0 | 1.0451 | 1.0251 | 6.2 | |
| 12:30 | 1 hr. | 10 c.c. | 23.1 | 17.1 | 10.8 | 1.0440 | 1.0255 | 6.33 | |
| 12:40 | 10 min. | | | | | | | | |
| | 1 hr. | 20 min. | 4 c.c.* | — | 21.5 | — | — | 1.0266 | 6.72 |
| | 20 min. | | | | | | | | |
| Heart's blood | | | | | | | | | |
| 12:55 | 1 hr. | 10 c.c. | 55.6 | 40.5 | 12.7 | 1.0452 | 1.0280 | 7.2 | |
| | 35 min. | | | | | | | | |
| 1:00 | 1 hr. | | | | | | | | |
| | 40 min. | | | | | | | | |
| | | | Portal vein blood,—57.8 mg. % | | | | | | |
| | | | Pericardial fluid,—41.2 mg. % | | | | | | |

*Blood did not flow well from artery, because of very low pressure.

REPEATED WITHDRAWAL OF HEART BLOOD*

Cat 3707. Weight: 2.665 Kg.

Sex: Male

Anesthesia: none

Jan. 21, 1937

| TIME | AMOUNT REMOVED | WHOLE BLOOD K MG. % | SERUM K MG. % | SERUM SPECIFIC GRAVITY | SERUM PROTEIN GM. % | REMARKS |
|---------|----------------|---------------------|---------------|------------------------|---------------------|------------------------------|
| Jan. 20 | | 28.8(c)† | | | | Fasting, healthy, adult cat |
| 7:20 | | | | | | Tied on board for experiment |
| Jan. 21 | | | | | | |
| 12:20 | | | | | | |
| 12:30 | 10 c.c. | 26.8 | — | 1.0293 | 7.6 | |
| 12:45 | 10 c.c. | 26.4 | 22.2 | 1.0284 | 7.3 | |
| 1:05 | 16 c.c. | — | 25.3 | 1.0266 | 6.7 | |
| 1:15 | 14 c.c. | 29.4 | 23.3 | 1.0268 | 6.8 | Air hunger |
| 1:30 | 16 c.c. | 32.3 | 25.3 | 1.0269 | 6.8 | |
| 1:50 | 10 c.c. | 26.7 | 20.4 | 1.0254 | 6.3 | |
| 2:05 | 10 c.c. | — | 28.1 | 1.0259 | 6.5 | Nictitating membrane out |
| 2:25 | | | | | | Extremities cold |
| 2:26 | 10 c.c. | 57.4 | 41.7 | 1.0265 | 6.6 | Convulsion |
| | | | | | | Very weak; gasping for air |
| 2:30 | | | | | | Dead |
| | Total | | | | | |
| | 96 c.c. | | | | | |

*Calculated original blood volume: 160 c.c.

†(c)—Capillary blood.

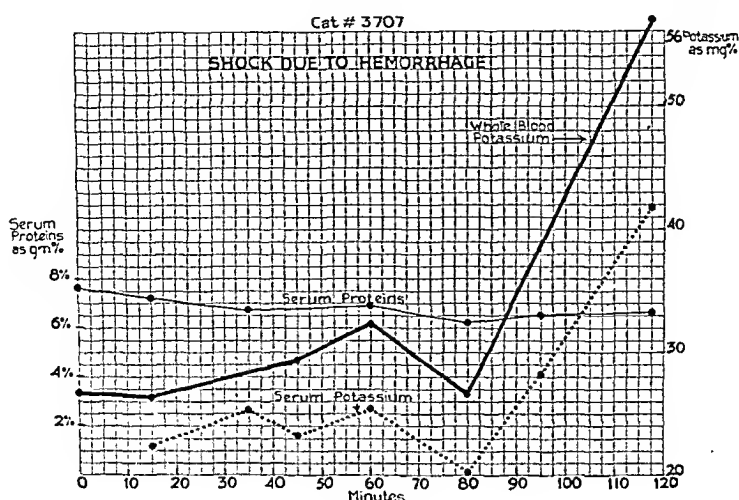


Fig. 1.

TABLE I (CONT'D)

EFFECT OF REPEATED WITHDRAWAL OF HEART BLOOD ON SPECIFIC GRAVITY OF BLOOD, BLOOD PRESSURE, SERUM, AND WHOLE BLOOD POTASSIUM

Cat 3752. Adult, male
Dec. 17, 1937

| TIME | AMOUNT BLOOD REMOVED | WHOLE BLOOD K MG. % HEART | SERUM K MG. % HEART | SPECIFIC GRAVITY BLOOD HEART | BLOOD PRESSURE SYSTOLIC | REMARKS |
|--------------|--|------------------------------------|---------------------------|---------------------------------------|-------------------------------|---|
| P.M. 3:50 | (Tied on board and, under local anesthetic, femoral artery exposed for recording blood pressure) | | | | | |
| 4:00 | | | | | 120 | |
| 4:05 | 10 c.c. | 22.6 | 19.4 | 1.0473 | | Blood from heart |
| 4:10 | | | | | 136 | |
| 4:17 | | | | | 154 | |
| 4:20 | 10 c.c. | 20.4 | 17.6 | 1.0463 | | Blood from heart |
| 4:25 | | | | | 110 | |
| 4:30 | 10 c.c. | 20.8 | 17.7 | 1.0448 | 110 | Blood from heart; beginning of panting |
| 4:35 | | | | | 98 | Blood from heart |
| 4:40 | 10 c.c. | 16.4 | 15.9 | 1.0435 | 85 | Passed urine |
| 4:45 | | | | | 88 | |
| 4:50 | 5 c.c. | 18.3 | 18.2 | - | 58 | Blood from heart |
| 4:52 | | | | | 62 | Marked panting with tongue out |
| 5:05 | | | | | 78 | |
| 5:10 | 10 c.c. | 17.8 | 18.3 | 1.0403 | 64 | Blood from heart |
| 5:15 | | | | | 40 | |
| 5:20 | | | | 1.0380 | 44 | Blood from femoral artery |
| 5:22 | 10 c.c. | 16.6 | 15.7 | 1.0395 | 40 | Pallor of tongue and mucous membranes; panting; sluggish response to stimuli; allowed to remain in this state |
| 6:45 | 10 c.c. | 48.1 | 45.7 | 1.0449 | 0 | Blood withdrawn just as animal expired |

TABLE I (CONT'D)

EFFECT OF REPEATED WITHDRAWAL OF HEART BLOOD

Cat 3755. Weight: 3.911 Kg.

Sex: male

Anesthetics: local

Dec. 11, 1937

[illegible]

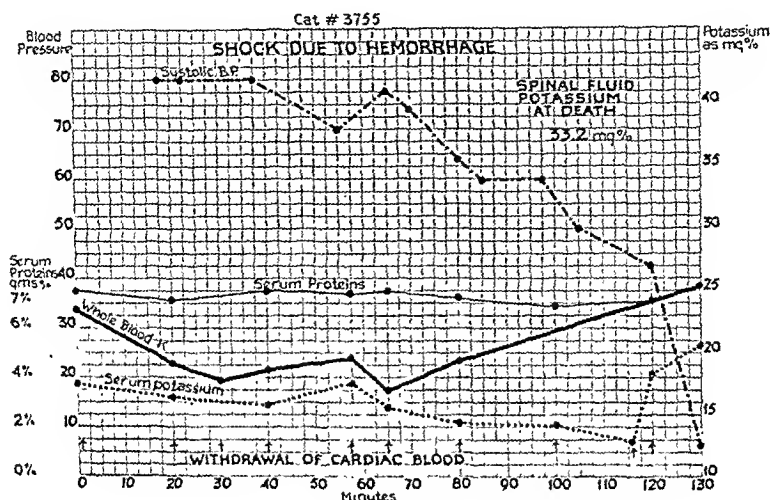


Fig. 2.

TABLE I (CONT'D)

MILD TRAUMA UNDER SODIUM AMYTAL ANESTHESIA
(70 MG./KG. 1.61 ML. AND 1 ML.)

Cat 3641. Weight: 2,800 Kg.

Sex: female

Oct. 13, 1936

| TIME | RELATIVE TIME AFTER TRAUMA | BLOOD K MG. % | SPECIFIC GRAVITY WHOLE BLOOD | REMARKS |
|-------|----------------------------------|---------------------|---------------------------------------|--|
| A.M. | | | | |
| 9:49 | | | | 1.61 ml. Na amytal intraperitoneal |
| 11:05 | | | | Cannulation of carotid completed |
| 11:30 | | | | 1 ml. Na amytal intraperitoneal |
| 11:45 | 0 | 21.6 | 1.0440 | |
| P.M. | | | | |
| 12:00 | 0 | 17.3 | 1.0469 | Pound thighs with rubber hammer at 10-min. intervals. |
| 12:11 | | | | |
| 12:17 | 17 min. | 14.1 | 1.0479 | |
| 12:25 | | | | |
| 12:35 | | | | |
| 12:50 | 50 min. | 15.7 | 1.0481 | |
| 1:00 | 1 hr.* | 21.1 | (h) 1.0486 1.0481 | Died suddenly during trouble with (h) clotted canula |

*No marked K changes in 1 hr. with amytal and pounding; cf. Seeley et al.

TABLE I (CONT'D)
 TRAUMA UNDER AMYTAL*
Cat 3644. Weight: 3,600 Kg.
Sex: female
Oct. 22, 1936

| TIME | RELATIVE TIME AFTER INJECTION OF AMYTAL | WHOLE BLOOD K MG. % | REMARKS |
|-------|--|------------------------------|--|
| A.M. | | | |
| 11:00 | 0 | 27.5 | Healthy, adult, female |
| 11:18 | 18 min. | 24.8 | 2.5 ml. 10% Na amytal (70 mg. kg.) |
| 11:25 | | | Animal unconscious |
| 11:35 | | | Temperature, 99.6°; heart rate, 200; respira- tions, 24 |
| 11:37 | 37 min. | 26.3 | Crushed left hind leg by pounding |
| P.M. | | | |
| 12:30 | 1 hr. 30 min. | 22.9 | |
| 12:40 | | | Right thigh pounded |
| 12:45 | | | Temperature, 97.8°; heart rate, 171; respira- tions, 26 |
| 1:00 | 2 hr. | 24.7 | |
| 1:30 | 2 hr. 30 min. | 24.3 | Temperature, 99.0°; heart rate, 198; respira- tions, 40 |

*No change in K under amytal in spite of pounding of legs.

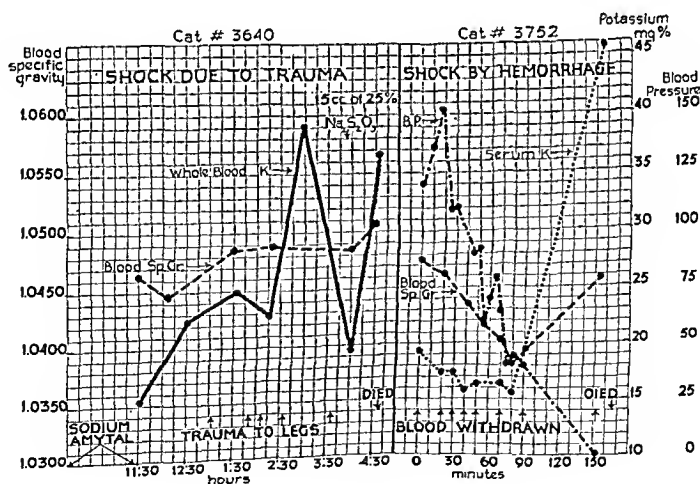


Fig. 3.

TABLE I—CONT'D
 SEVERE TRAUMA UNDER AMYTAL

Cat 3640. Weight: 2.522 Kg.
 Sex: female
 Anesthesia: sodium amytal (70 mg./kg.)
 Oct. 13, 1936

| TIME | RELATIVE TIME AFTER TRAUMA- TIZATION | WHOLE BLOOD K AS MG. % | SPECIFIC GRAVITY WHOLE BLOOD | SYSTOLIC BLOOD PRESSURE | TEMPER- ATURE (RECTAL) | PULSE | REMARKS |
|-------|--|---------------------------------|---------------------------------------|-------------------------------|------------------------------|-------|--|
| A.M. | | | | | | | |
| 9:47 | | | | | | | 1.76 ml. Na amy- tal intraperito- neal |
| 10:30 | | | | | | | Cannulation of carotid finished; 10 ml. blood lost |
| 11:25 | 0 | 15.2 | 1.0462 | 120 | | | 1 ml. Na amytal intraperito- neally |
| P.M. | | | | | | | |
| 12:30 | 0 | 22.1 | 1.0447 | | | | |
| 12:45 | | | | | 96° | | Crush and pound left hind leg |
| 1:20 | 35 min. | 24.8 | 1.0486 | | 95.8° | | |
| 1:33 | | | | | 95.0° | | |
| 1:35 | | | | | | | Pound both legs |
| 1:46 | | | | | | | Pound both legs |
| 1:58 | | | | | 96.1° | | |
| 2:10 | 1 hr. 25 min. | 22.5 | 1.0487 | | | | |
| 2:25 | | | | 110 | | | Pound both legs |
| 2:40 | 1 hr. 55 min. | 39.4 | 1.0485 | | | 120 | |
| 3:05 | | | | 110 | 101.0° | | Pound both legs |
| 3:07 | | | | | | | Pound both legs |
| 3:25 | | | | | | | Anticoagulant 25% Na ₂ S ₂ O ₄ run in |
| 3:28 | | | | 130 | | | |
| 3:55 | | | | 85 | 101.4° | | |
| 4:00 | 3 hr. 15 min. | 19.3 | 1.0487 | | | | |
| 4:25 | | | | 60 | 101.6° | 160 | |
| 4:30 | 3 hr. 45 min. | 36.5(h) | 1.0496(h) | 60 | 103.0° | | |
| 4:33 | | | | | | | Dead |

TABLE 1 (CONT'D)

EFFECT OF SEVERE MUSCLE TRAUMA AND MULTIPLE FRACTURES UNDER ETHER

*Cat 3650. Weight: 3.686 Kg.**Sex: male, adult**Dec. 7, 1936*

| TIME | RELATIVE TIME | CAPILLARY BLOOD K AS MG. % | SPECIFIC GRAVITY CAPILLARY BLOOD | WEIGHT % LOSS | REMARKS |
|---------------|----------------|---|----------------------------------|----------------|--|
| P.M. | | | | | |
| 2:30 | | 33.8 | 1.0525 | | Fasting |
| 3:10 | 0 | Under ether anesthesia, both hind legs crushed | | | |
| 3:20 | 10 min. | 29.9 | 1.0579 | | Respirations, 104 |
| 3:40 | 30 min. | 38.2 | 1.0566 | | Respirations, 190; panting |
| 4:10 | 1 hr. | 36.6 | 1.0568 | 3.600 -2.5% | |
| 5:10 | 2 hr. | 34.2 | | | Restless |
| 6:15 | 3 hr. 5 min. | 29.7 | 1.0576 | | |
| 7:10 | 4 hr. | 23.1 | 1.0587 | 3.572 -3.2% | Ears cold; blood dark and flows slowly |
| 7:25 | | | | | Respirations, 38 |
| 7:45 | 4 hr. 35 min. | 28.6 | 1.0601 | | Blood very dark; respirations, 35 |
| 8:25 | 5 hr. 15 min. | 33.5 | 1.0568 | 3.560 -3.5% | Ears and extremities cold |
| 9:20 | 6 hr. 10 min. | 35.8 | 1.0553 | 3.543 -4.0% | |
| 9:40 | 6 hr. 30 min. | Under ether anesthesia, right front leg crushed | | | |
| 9:45 | 6 hr. 35 min. | | 1.0553 | | |
| 10:00 | 6 hr. 50 min. | 25.7 | | | Respirations, 40 |
| 10:25 | 7 hr. 15 min. | 29.3 | 1.0556 | | Much salivation |
| 10:55 | 7 hr. 45 min. | 27.0 | 1.0551 | 3.500 -5.0% | |
| 11:50 | 8 hr. 40 min. | 30.0 | 1.0550 | | Blood flow poor; pulse, 200 |
| <i>Dec. 8</i> | | | | | |
| A.M. | | | | | |
| 12:50 | 9 hr. 40 min. | 33.6 | 1.0565 | 3.500 -5.0% | Blood clots readily |
| 2:10 | 11 hr. | 28.7 | 1.0560 | | Condition same |
| 3:10 | 12 hr. | 29.9 | 1.0560 | | |
| 4:10 | 13 hr. | 31.3 | 1.0560 | 3.450 -6.5% | |
| 4:15 | 13 hr. 5 min. | | | | Pericardial fluid, 49.5 mg. % |
| | | Heart blood | | | |
| 4:18 | 13 hr. 8 min. | 31.5 | | | 5 c.c. withdrawn |
| 4:40 | 13 hr. 30 min. | Ether anesthesia, legs traumatized and massaged | | | |
| 4:55 | 13 hr. 45 min. | 28.0 | 1.0547 | | Convulsion |

TABLE I (CONT'D)

EFFECT OF SEVERE MUSCLE TRAUMA AND MULTIPLE FRACTURES UNDER ETHER—
CONT'D

| TIME | RELATIVE TIME | CAPILLARY BLOOD K AS MG. % | SPECIFIC GRAVITY CAPILLARY BLOOD | WEIGHT % LOSS | REMARKS |
|------|----------------|----------------------------|----------------------------------|---------------|--|
| 5:35 | 14 hr. 25 min. | 33.0 | 1.0568 | | Legs massaged; respirations, 112 irregular |
| 6:10 | 15 hr. | 40.5 | | | |
| 6:15 | 15 hr. 5 min. | | | | Dead |

Autopsy.—Severe muscle trauma with some extravasation of blood; ruptured muscles very dry

Compound fracture of both right and left humerus

Compound fracture of right femur

Compound fracture of left tibia and fibula

Lungs: collapsed; petechial hemorrhages on surface

Heart: in diastole

Stomach: dilated; contained hair ball but not fluid

Small intestine: cyanotic

Large intestine: filled with hard feces

Liver: red, soft, slightly mottled

Spleen: red, leathery in consistency

Kidneys: large, soft, pale brown

Adrenals: soft, tan color

Bladder: partially filled

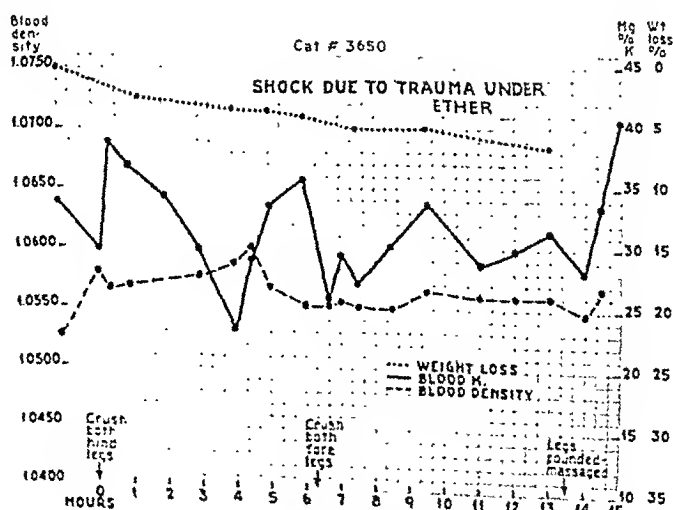


Fig. 4.

TABLE I (CONT'D)
EFFECTS OF INTESTINAL MANIPULATION

Cat 3702. Weight: 3.657 Kg.

Sex: male

Anesthesia: ether

Jan. 11, 1937

| TIME | RELATIVE TIME AFTER MANIPULA- TION | CAPILLARY WHOLE BLOOD K AS MG. % | SPECIFIC GRAVITY CAPILLARY BLOOD | REMARKS |
|--------------------------|--|--|---|---|
| Jan. 9 5:45 | 0 | 26.0 | — | Fresh, healthy adult |
| Jan. 11 P.M. 12:40 | 0 | 25.0 | 1.0512 | Nonfasting; weight, 3856 gm. |
| 12:45 | Operation under ether; viscera manipulated in a towel for 25 min.; abdomen closed; weight, 3,800 gm. | | | |
| 1:15 | 5 min. | 24.9 | 1.0500 | Respirations, 180 |
| 1:35 | | | | Respirations, 260; urinated and vomited much food |
| 2:20 | 1 hr. 5 min. | 19.6 | 1.0483 | Respirations, 182; vomited thin brownish fluid |
| 2:20 | | | | Weight, 3,457 gm. |
| 3:20 | 2 hr. 5 min. | 22.9 | 1.0512 | Weight, 3,429 gm.; mucous membranes dry |
| 3:40 | | | | Respirations 60, irregular; weight: 3,417 gm. |
| 4:20 | 3 hr. 5 min. | 34.3 | 1.0529 | Respirations 100; blood obtained with some difficulty |
| 5:00 | 3 hr. 45 min. | Heart blood 24.2 | Heart blood 1.0508 | |
| 6:30 | 5 hr. 15 min. | Heart serum 26.0 | 1.0535 | |
| 7:45 | 6 hr. 30 min. | Heart blood 41.0 | 1.0518 | Dead |
| | | Peritoneal fluid 57.1 | | |

Autopsy.—Peritoneal cavity filled with bloody fluid. Intestines contracted. Much subserosal ecchymoses where gut was handled. Liver and spleen leathery in consistency. Gall bladder filled. Pancreas pale. Kidneys tense and swollen. Adrenal cortex gray and shrunken; hemorrhage between cortex and medulla. Heart in diastole. Lungs pink and collapsed with few petechial hemorrhages on surface.

TABLE I (CONT'D)
EFFECT OF MANIPULATION OF INTESTINES WITH ADRENALS TIED OFF
Cat 3706. Weight: 3.742 Kg.
Sex: male
Anesthesia: ether
Jan. 21, 1937

| TIME | RELATIVE TIME | CAPILLARY BLOOD K AS MG. % | CAPILLARY BLOOD SPECIFIC GRAVITY | REMARKS |
|--|---------------|----------------------------|----------------------------------|--|
| Jan. 20 7:15 | | 25.8 | | Healthy, adult, nonfasting cat |
| Jan. 21 A.M. 11:00 | 0 | 22.1 | 1.0553 | Fasting; tied on board |
| 11:15 | | 17.6 | 1.0551 | Ether anesthesia, operation Both adrenal glands tied off |
| 11:25 | 15 min. | 21.4 | 1.0483 | Heart rate, 220; respirations, 28 |
| 11:30 | | 28.3 | | Rough manipulation of intestines |
| 11:45 | 30 min. | | | Operation finished |
| 11:50 P.M. 35 min. | | | | Nictitating membranes out |
| 12:15 | 1 hr. | 19.5 | 1.0498 | Recovered from anesthesia. |
| 12:45 | 1 hr. 30 min. | 22.1 | 1.0528 | Marked asthenia; some oozing of blood from wound |
| 1:35 | 2 hr. 20 min. | 38.5 | 1.0503 | Defecated |
| 2:10 | 2 hr. 55 min. | Heart blood | 1.0543 | Struggled |
| 4:00 | 4 hr. 45 min. | 22.4 | 1.0544 | Extremities cold; in shock |
| 5:00 | 5 hr. 45 min. | 25.8 | | Extremities cold |
| 5:55 | | | | Labored breathing, rate 98; extremities cold. |
| 6:05 | 6 hr. 50 min. | 30.6 | | Very restless |
| <i>Autopsy.</i> —Lungs: collapsed, pink; no fluid in pleural cavity | | | | |
| Heart: some bloody fluid found in pericardial cavity | | | | |
| Peritoneal cavity: much bloody fluid; serosa showed trauma, with extravasation of blood | | | | |
| Intestines: contracted with extensive subserosal hemorrhage; thin fibrinous adhesions present; the ligatured adrenals pale | | | | |
| Kidneys: soft, swollen, brown in color; bladder filled | | | | |

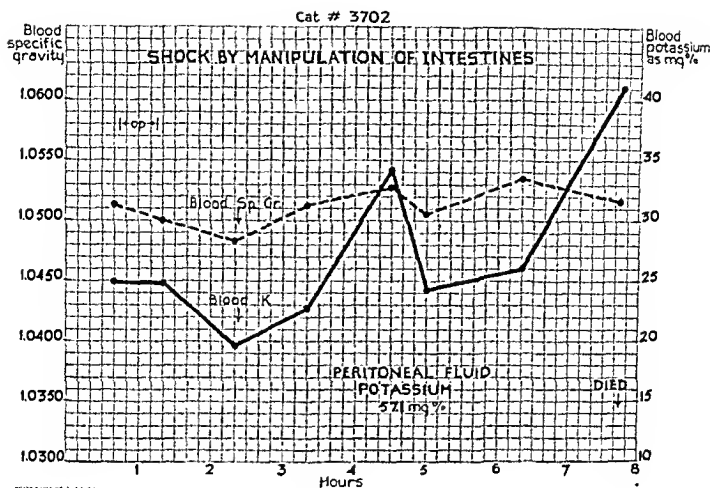


Fig. 5.

beds, to capillary leakage and filling of tissue spaces, or finally to a loss of extracellular body fluids by hydration of cells. Maintenance of a constant body weight would favor the explanations of internal redistribution; whereas, a weight decrease would strengthen the view of anhydremia by actual fluid loss from the body.

Others believe that the presence of some toxin is necessary to explain all of the phenomena. This toxin was first thought to be histamine, but the term "H" substance is now generally used for this histamine-like constituent of tissues which is released by injury. It is probable that potassium is an important "H" substance always available.

The relation of adrenal cortex function to shock is attested by an extensive literature. Treatments of various types of shock, such as traumatic (Swingle and Parkins, 1935), anaphylactic (Wolfram and Zwemer, 1935; Dragstedt and others, 1937), histamine (Wyman and Tum Suden, 1937), and the toxin of intestinal obstruction (Heuer and Andrus, 1934; Wohl and others, 1937) are represented. The evidence that potassium regulation is a function of the adrenal cortex (Zwemer and Sullivan, 1934; Zwemer and Truszkowski, 1936, 1937; Truszkowski and Zwemer, 1938) is receiving increasing support (Allers, 1936; Harrop, 1936; Nilson, 1937; Thorn, 1937). Since a marked increase in extracellular potassium is injurious to cells and injured cells lose potassium, a vicious cycle ending in death may be initiated if the plasma K is allowed to rise. Therefore, rational therapy for shock should include measures which enable the body to restore and maintain a normal potassium level in body fluids. These are sodium salt therapy, adequate but not excessive fluid administration (Seudder, Zwemer, and Whipple, 1938), and cortin therapy.

TABLE II
WHOLE BLOOD K IN SECONDARY SHOCK IN CATS.

| CAT NO. | INITIAL K MG. % | PROCEDURE USED TO PRODUCE SHOCK | TIME OF SURVIVAL | K VALUE IN SHOCK MG. % | TOTAL NUMBER OF SAMPLES TAKEN |
|---------|-----------------|---------------------------------|------------------|------------------------|-------------------------------|
| 3655 | 27.7 | 50 cm. strangulated loop | 9 hr. | 36.4 | 9 |
| 3630 | 27.5 | Jejunal loop | 14 hr. | 39.3 | 9 |
| 3631 | 20.2 | 20 cm. strangulated loop | 30 hr. | 66.6 | 15 |
| 3632 | 17.3 | Anemic jejunum loop | 45 hr. | 29.6 | 5 |
| 3713 | 22.7 | Duodenostomy | 3 days | 44.2 | 11 |
| 3636 | 30.0 | Esophageal obstruction | 3½ days | 52.0 | 11 |
| 3639 | 21.8 | Duodenal obstruction | 3½ days | 39.7 | 11 |
| 3718 | 35.6 | Duodenostomy | 4 days | 61.5 | 18 |
| 3712 | 29.1 | Jejunostomy | 4 days | 84.0 | 9 |
| 3717 | 37.1 | Jejunostomy | 4 days | 86.6 | 9 |
| 3721 | 25.5 | Gastrostomy | 5 days | 37.5 | 11 |
| 3724 | 22.6 | Gastrostomy | 5 days | 40.9 | 16 |
| 3709 | 19.8 | Ileostomy | 5 days | 84.8 | 10 |
| 3649 | 24.3 | Pancreatitis | 5 days | 52.3 | 10 |
| 3638 | 31.7 | Duodenal obstruction | 7½ days | 42.6 | 16 |
| 3710 | 21.1 | Ileostomy | 10 days | 48.0 | 21 |

In attempting to correlate the divergent theories concerning the causes of death in adrenal insufficiency (Zwemer and Truszkowski, 1937), intestinal obstruction (Seudder, Zwemer, and Truszkowski, 1937), and intestinal fistulas (Seudder and Zwemer, 1937) consideration of potassium as the unknown toxin seemed to make the various explanations more compatible. Since in a condition of shock our present data show a rise in blood potassium to high levels, it seems reasonable to believe that inadequate potassium regulation is also a factor which must be considered in any explanation of shock.

SUMMARY

The remarkably constant regulation of potassium by the body is altered during the condition of shock. Fluctuations suggest alternate success and failure of regulation, and a sudden increase precedes death. Peripheral blood samples are not always indicative of the changes taking place internally, especially in the fluids of closed cavities, such as pericardial and cerebrospinal fluids (Table III).

TABLE III
POTASSIUM CONTENT OF SOME BODY FLUIDS AT TIME OF DEATH FROM SHOCK

| | |
|-------------------------|--------------|
| Cerebrospinal fluid | 32.9 mg. % K |
| Lymph | 30.3 mg. % K |
| Pericardial fluid | 49.8 mg. % K |
| Peritoneal fluid | 57.1 mg. % K |
| Transected tissue fluid | 77.9 mg. % K |

Detailed data from twelve cats (Table I), and supplementary information from sixteen other animals (Table II) are presented.

We take this opportunity to thank Dr. Richard Truszkowski for his assistance in the amytal experiments.

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STUDIES OF SODIUM, POTASSIUM, AND CHLORIDES OF BLOOD SERUM IN EXPERIMENTAL TRAUMATIC SHOCK, SHOCK OF INDUCED HYPERPYREXIA, HIGH INTESTINAL OBSTRUCTION, AND DUODENAL FISTULAS

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IN VIEW of the profound disturbances of tissue metabolism, blood volume, and water balance associated with traumatic shock, hyperthermic shock, and high intestinal obstruction, chemical alterations of the blood would seem inevitable. There has accumulated much evidence to show that this is true.

This investigation had for its purpose the determination of the extent to which certain of these changes, namely the alterations in the relative proportions of serum sodium and potassium, play in the production of symptoms and in the cause of death. It will be observed from an analysis of the results that there exists no constant relationship, also that the quantitative changes in both sodium and potassium appear to be incidental to the changes in blood volume and concentration rather than the cause of the prostration and death.

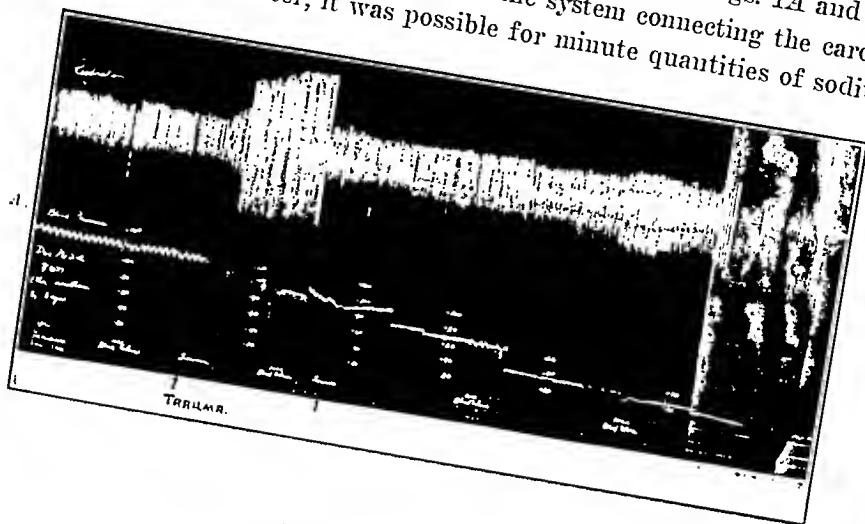
EXPERIMENTS

Sixteen dogs were used for nineteen experiments. Chemical analyses were made upon blood serum from blood aspirated from the heart. In one animal, for purposes of comparison, determinations were made upon both whole blood and serum from samples of blood taken simultaneously. Contrary to certain reports, we found a wide variation in the content of sodium and potassium in serum as compared to whole blood. Blood chlorides were determined by the method described by Saifer and Kornblum and the sodium and potassium by a modification of the methods of Kramer and Tisdall and Saht described by Morgulis and Perley. With only a few exceptions, each analysis was run in duplicate.

TRAUMATIC SHOCK

After taking blood for normal control determinations, 3 animals were anesthetized with ether and traumatic shock was induced by contusing both lower extremities. In 2 animals, Dogs 1R and 2R, the trachea and carotid artery were cannulated and connected to record-

ing manometers mounted on a kymograph. Continuous records of respiration, pulse rate and blood pressure were made throughout the experiments. Portions of these records are shown in Figs. 1A and 2A. Because sodium citrate was used in the system connecting the carotid artery and manometer, it was possible for minute quantities of sodium



Dog 22 Traumatic Shock

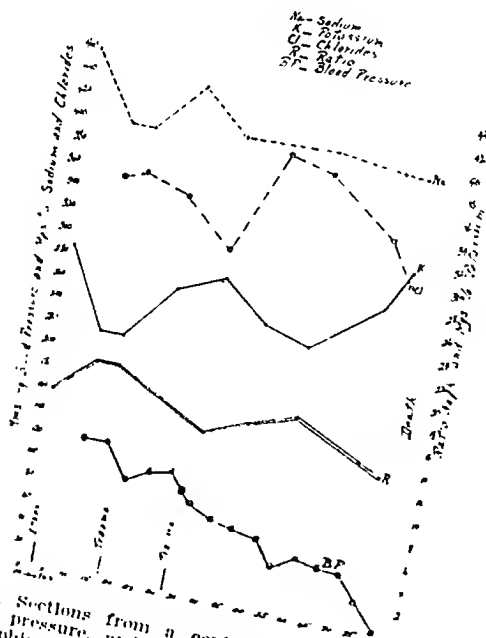


FIG. 1 -- Dog 22. A, Sections from a continuous kymographic record showing changes of pulse, blood pressure, and respiration with progressive development of traumatic shock. B, Graphic record of changes of blood pressure recorded in A and of serum sodium, potassium, and chlorides during the development of traumatic shock. Note fall of sodium and potassium with induction of ether anesthesia, a sharp rise to nearly normal levels after trauma and, after a second recession, a rise of potassium to a level slightly above normal as shock became profound.

to enter the blood stream. For this reason the blood studies in the third animal, Dog 4L, were made without recording blood pressure. Since in this animal the analyses did not differ significantly from those in which blood pressure records were made, it would appear that if sodium entered the blood stream it did so in too small quantities to influence the levels of sodium and potassium of the serum.

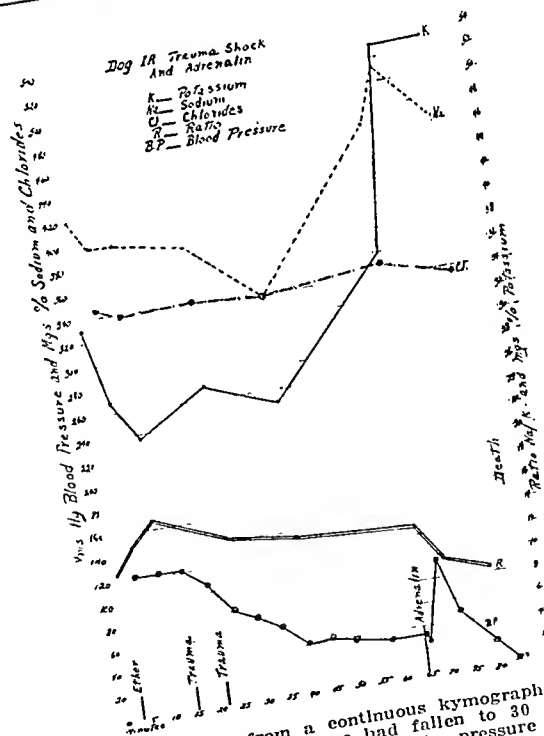
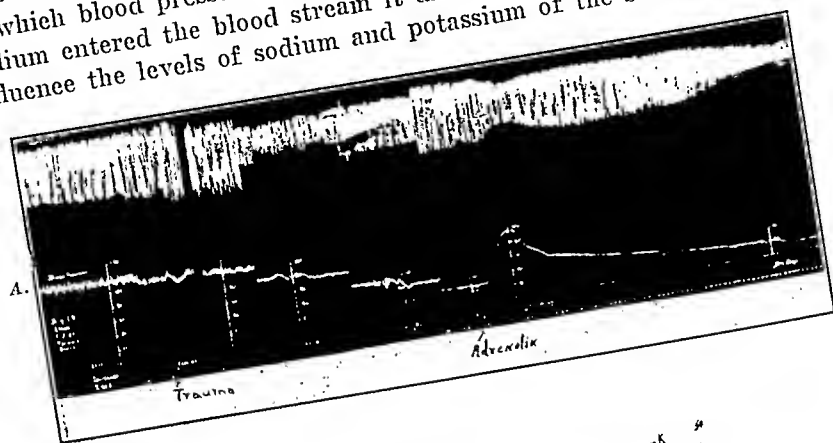


Fig. 2.—Dog 1R. A, Sections from a continuous kymographic record of induced traumatic shock. When the blood pressure had fallen to 30 mm. Hg, 7 mins. of adrenalin was given intracardially. Immediately the pressure rose to 95 mm. and then fell progressively to zero with death. B, Plotted with the blood pressure curve taken from the kymographic record illustrated in A are the concomitant fluctuation of serum sodium, potassium, and chlorides. Note the initial fall of sodium and potassium with induction of anesthesia, the gradual return to preoperative levels with development of shock, and then the precipitous rise to very high levels with the elevation of blood pressure which followed injection of adrenalin.

Detailed analyses of the results of the experiments are shown in Figs. 1A and B, 2A and B. They consistently showed the following changes: (1) A sharp fall of both sodium and potassium with the induction of ether anesthesia. (2) A slight rise but continued subnormal level of both sodium and potassium with the progressive fall in blood pressure until the degree of shock became profound and terminal. There was then a sharp rise of potassium in all animals. In one, Dog 1R, it mounted to an extremely high level; in another, Dog 2R, to a level slightly above the preoperative level; and in the third, Dog 4L, it never reached the preoperative level. In Dog 1R adrenalin was given intracardially 1½ minutes before the first blood sample, which showed a very high level of potassium, was taken. In this case we believe that the adrenalin was probably at least partially responsible for this response because simultaneously there was a precipitous rise of blood pressure. (3) No significant changes in blood chlorides. (4) The sodium-potassium ratio rose with induction of anesthesia and progressively fell as the blood pressure dropped.

INDUCED HYPERTHERMIA

In 4 dogs fever was induced and made to progress to a lethal degree in a heat chamber of Kettering design. As in the preceding experiment, continuous kymographic records were made of respirations, pulse, and blood pressure in 2 animals but omitted in 2 dogs to avoid the possible influence of the sodium in sodium citrate used in the manometric system. The anesthesia consisted of amytal administered orally and supplemented by ether induction.

Composite data of the experimental results are shown in Fig. 3A and B and in Tables I and II. They may be summarized as follows: (1) Induced fever became lethal at 112° F. (2) Blood pressure began to fall as the temperatures reached 104° and fell rapidly to shock levels as temperatures mounted above 108°. (3) Potassium fell with the induction of anesthesia and then rose to levels of 30 to 50 per cent above the normal control levels with the induction of fever.

TABLE I
Dog 500—HYPERTHERMIC SHOCK

| | RECTAL TEMPERATURE | SODIUM MG. % | CHLORIDES MG. % | POTASSIUM MG. % | CALCIUM MG. % |
|-------------------------------------|-----------------------|-----------------|--------------------|--------------------|------------------|
| 1. Normal control | 100.5 | 270 | 359 | 15.2 | 11.2 |
| 2. After induction of anesthesia | | 274 | 347 | 14.2 | 11.46 |
| 3. Hyperthermia, 30 min. | 108.2 | 245 | 353 | 12.8 | 10.70 |
| 4. Hyperthermia, 55 min. | 110.2 | 267 | 374 | 20.2 | 9.83 |
| Experimental error | | ± or -5% | ± or -2% | ± or -3% | ± or -1% |

TABLE II

Dog 502—HYPERTHERMIC SHOCK

| | RECTAL TEMPERATURE | SODIUM MG. % | CHLORIDES MG. % | POTASSIUM MG. % | CALCIUM MG. % |
|-------------------------------------|-----------------------|-----------------|--------------------|--------------------|------------------|
| 1. Normal control | 101.4 | 286 | 368 | 12.4 | 9.92 |
| 2. After induction of anesthesia | | 274 | 354 | 12.5 | 11.1 |
| 3. Hyperthermia, 40 min. | 106.0 | 254 | 360 | 6.5 | 10.37 |
| 4. Hyperthermia, 55 min. | 106.8 | 262 | 371 | 8.3 | 10.65 |
| 5. Hyperthermia, 60 min. | 107.5 | 255 | 373 | 10.5 | 10.46 |
| 6. Hyperthermia, 65 min. | 108.0 | 258 | 375 | 12.9 | 10.24 |
| 7. Hyperthermia, 90 min. | 110.0 | 282 | 373 | 12.9 | 10.15 |
| 8. Hyperthermia, 115 min. | 111.8 | 282 | 380 | 14.9 | 10.18 |
| Experiment error | | + or -4% | + or -2% | + or -5% | + or -1% |

The rise in potassium roughly paralleled the rise in fever in 3 animals, but in 1 it reached a maximum at a temperature of 106° and, although it then fell, it remained above the control level until the animal was in extremis. (4) Sodium and chlorides remained relatively unchanged in 3 dogs. In 1 the sodium fell consistently, falling to nearly one-half of its control level. (5) The sodium-potassium ratio showed a slight rise with induction of anesthesia and a fall with development of fever and shock.

Determinations of serum calcium were made in 2 dogs. In both a slight rise with induction of anesthesia was followed by a slight fall to the normal initial level or slightly below it.

INFLUENCE OF ETHER ANESTHESIA AND ADRENALIN

Determinations of these influences were undertaken because the serum potassium had shown a sharp drop constantly and consistently with induction of ether anesthesia in the experiments described above and had mounted to an excessively high level immediately after the administration of adrenalin in the one dog which received it while in profound shock.

The results are shown in the graphs, Fig. 4A-C. With both ether and adrenalin, potassium fell sharply but transiently and returned promptly to the normal control levels. At no time did the potassium rise above the normal control levels. Sodium and chlorides showed no significant change. The ratios of sodium and potassium varied inversely with the fluctuations of potassium.

HIGH INTESTINAL OBSTRUCTION

At varying levels and by various means, the duodenum was completely obstructed in 5 animals and the duodenum and proximal jejunum in 2 animals.

1. *Obstruction by Division.*—In 2 dogs obstruction was produced by severing the bowel and turning in the ends with two rows of sutures. In 1 dog the obstruction was made just below the pylorus; in the

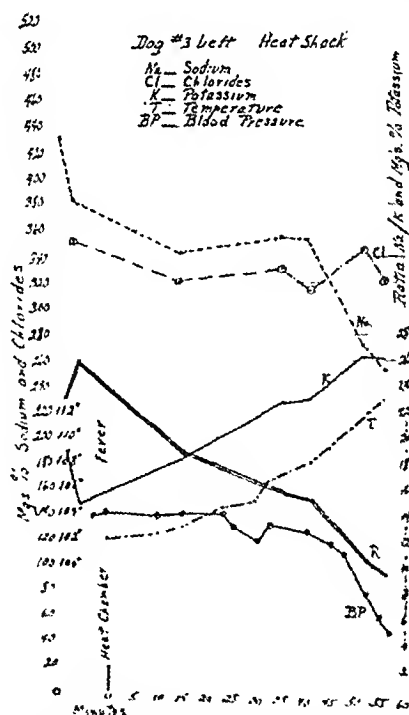
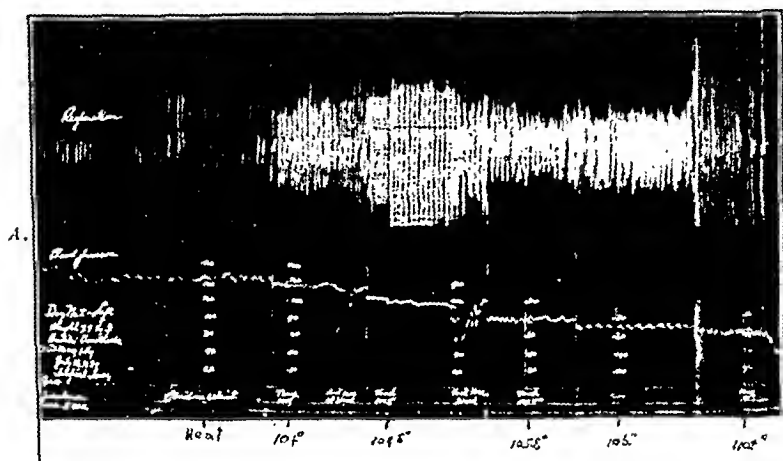


FIG. 3. Dog #3. A, Sections from a continuous kymographic record showing the progressive increase of both pulse and respiratory rates and progressive fall of blood pressure associated with the increasing hyperpyrexia. Respirations became profoundly increased in respect to both rate and amplitude. B, A composite graph of development of hyperpyrexia to its fatal termination. Note the parallel rises of temperature and potassium.

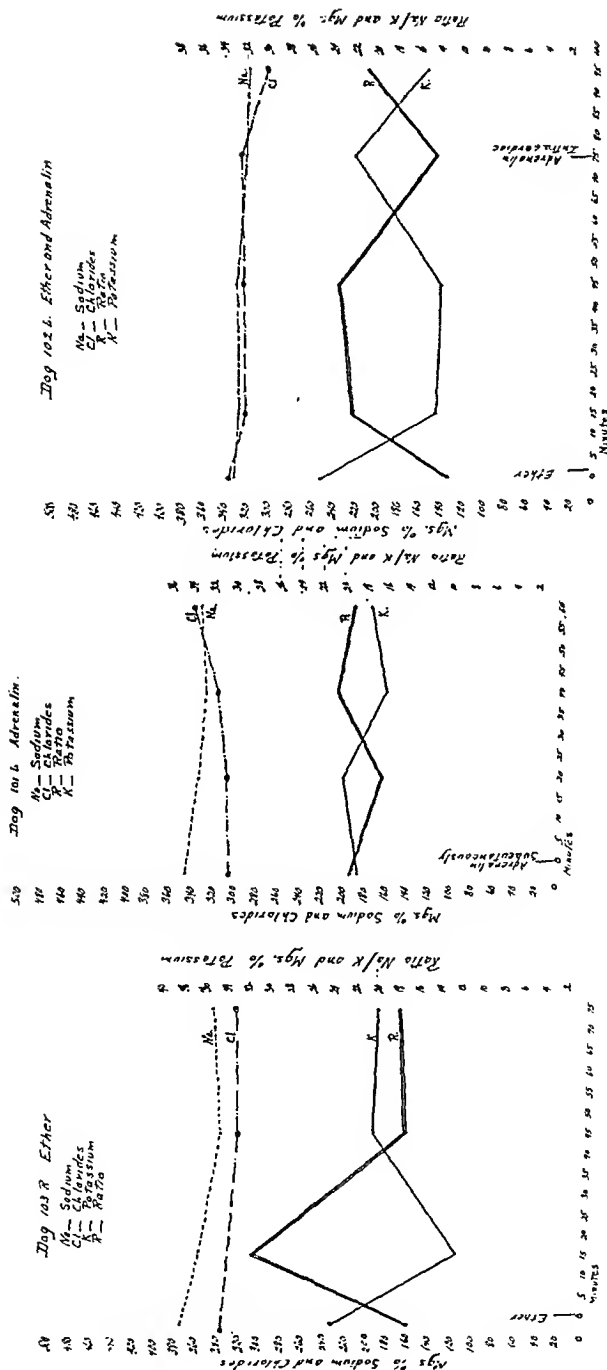


Fig. 4.—A, Changes in serum sodium, potassium, and chlorides associated with ether followed by a rise but failure to regain the normal preoperative levels. B, Changes in serum sodium, potassium, and chlorides following subcutaneous administration of 1 c.c. of adrenalin, 1:1,000. Note slight fall in potassium. C, The response to both ether and adrenalin. After the serum potassium had returned almost to its original, normal preanesthetic level, 0.5 c.c. of adrenalin, 1:1,000, was given intracardially. Note that this was followed immediately by a second drop in the level of potassium.

other, a few centimeters below the ampulla of Vater. Thus, in the dog with pyloric obstruction only gastric secretions were excluded from the intestinal tract. Bile and pancreatic and intestinal secretions could move down the tract unobstructed, but in the latter animal all of these secretions likewise were excluded. However, the dog with

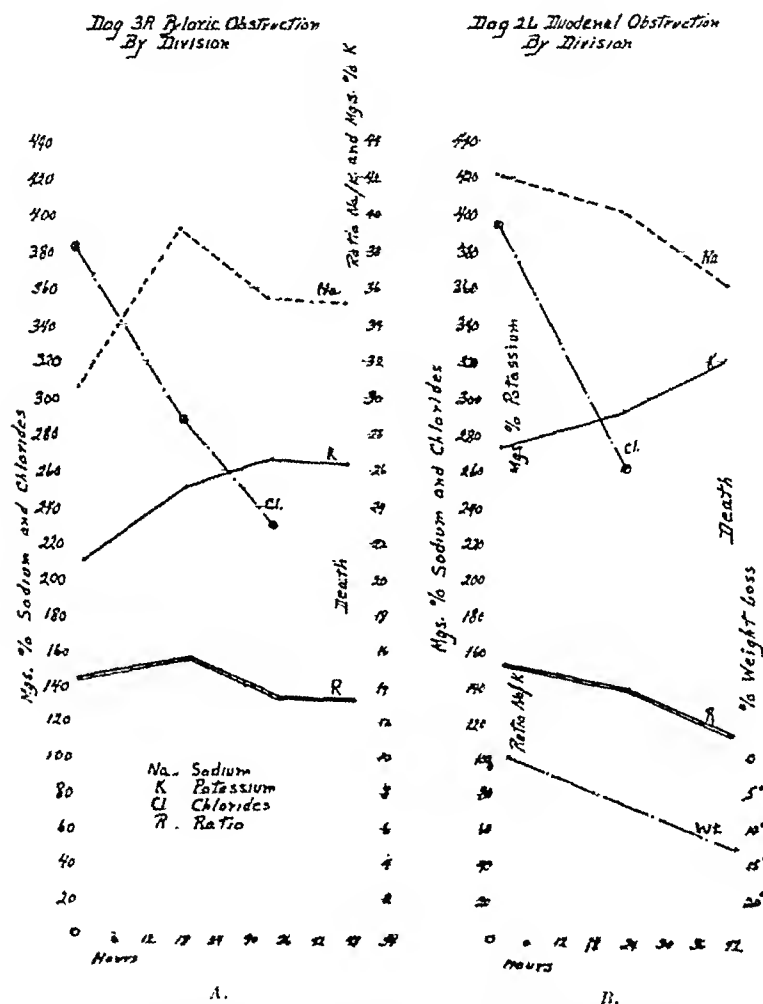


FIG. 5.—A, Pyloric obstruction by division. Note the large decrease in chlorides and a small but sustained increase of potassium. B, Duodenal obstruction by division; a marked decrease in chlorides and a small progressive increase in potassium.

obstruction above the ampulla lived 52 hours, 10 hours longer than the one obstructed below it.

As shown in the Protocols 1 and 2 and in Fig. 5A and B, there was consistently a precipitous fall in chlorides, a rise of potassium to 18 and 26 per cent above preoperative levels, and a slight fall in the sodium-potassium ratio. In the animal with pyloric obstruction there

was a rise in sodium, while in the one with obstruction below the ampulla of Vater the sodium fell progressively. The latter animal lost 13 per cent of its body weight.

PROTOCOL 1

PYLORIC OBSTRUCTION BY DIVISION

Dog 3R, male; weight, 12.3 kilo. On July 22, 1937, the duodenum was divided immediately distal to the pyloric sphincter and the ends were closed by inversion.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|--|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 102.0 | 382 | 307 | 21 |
| 9 | Considerable vomiting; dry and slightly apathetic | 102.8 | 288 | 393 | 25 |
| 26 | Weak, unsteady gait; apathetic, dry, gaunt | 104.0 | | | |
| 42 | Stands unwillingly; eyes contain mucus; muscles twitch | 103.0 | 230 | 355 | 26.6 |
| 50 | Refuses to stand; muscles twitch | 101.9 | | 350 | 26.4 |
| 60 | Death—Autopsy: peritoneal cavity clean, suture lines tight, stomach contracted, duodenum distended, heart normal, terminal bronchopneumonia both lungs | | | | |

2. *Obstruction by Simple Ligation.*—In 3 dogs the duodenum was obstructed immediately below the ampulla of Vater by simple ligation with broad strands of cotton tape. There was no interference with circulation. In all dogs the tape cut through the bowel, resulting in leakage and peritonitis in 1 dog, while in the other 2 the obstruc-

PROTOCOL 2

DUODENAL OBSTRUCTION BY DIVISION

Dog 2L, male; weight, 14.47 kilo. On July 22, 1937, the duodenum was divided 5 cm. below the ampulla of Vater and the ends were turned in.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|--|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 101.8 | 395 | 422 | 27.4 |
| 18 | Vomiting several times; apathy; dehydrated | 102.2 | | | |
| 25 | Some, but less vomiting; weak, but stands and wags tail slowly | 104.0 | 261 | 403 | 29.2 |
| 42 | Very weak, listless and unable to stand; eyes coated with mucus; irregular twitching of all the muscles | 100.0 | | 361 | 32.0 |
| 43 | Dead—Autopsy: abdomen dry and clean, suture lines tight, stomach and duodenum collapsed, below obstruction bowel slightly dilated; lungs clear, heart normal | | | | |

tion was released and spontaneous anastomosis occurred. The latter animals, after becoming almost moribund, completely recovered.

Consistently in all of these animals there was a large and rapid fall of chlorides and a lesser fall of sodium. Potassium increased from 18 to 30 mg. per cent in the dog which developed peritonitis but in the other 2 it not only promptly fell below the preoperative level but also remained below that level. The sodium-potassium ratios in all 3 animals varied inversely with the levels of potassium and all lost weight, 1 as much as 23 per cent. See Figs. 6A and B and 7 and Protocols 3, 4, and 5.

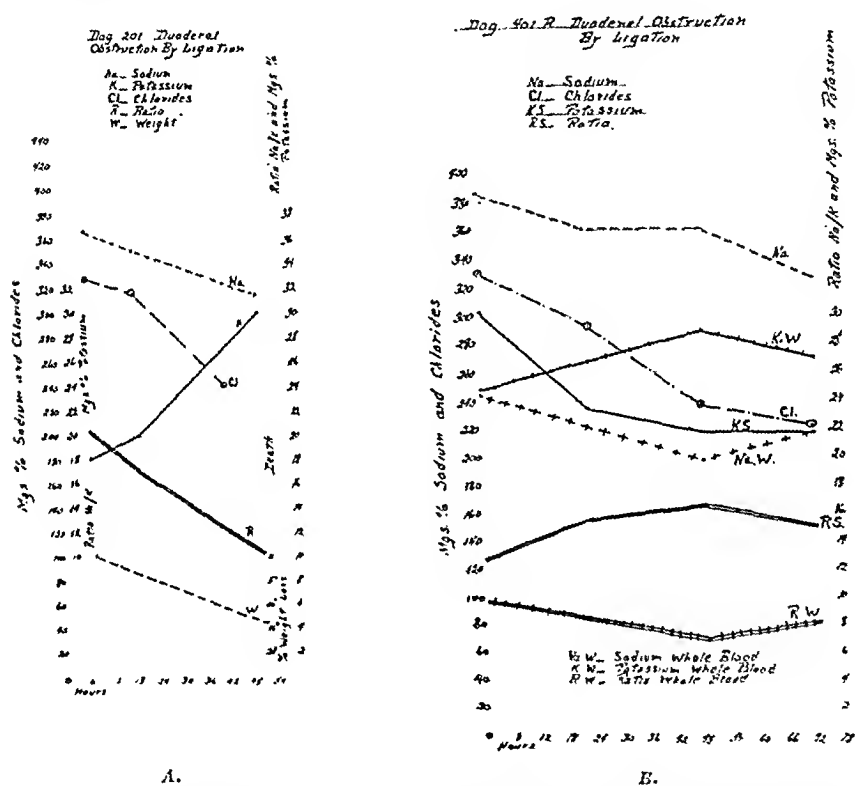


FIG. 6.—A, Duodenal obstruction by ligation. A large progressive decrease in chlorides and a large terminal increase in potassium. In addition to obstruction, autopsy revealed peritonitis. B, Duodenal obstruction with recovery. In general this experiment parallels that illustrated in Fig. 7. Determinations of sodium and potassium were made upon both serum and whole blood. The values are in no way comparable.

The records of 2 of these dogs deserve individual comment.

Dog 101R, 96 hours after simple ligation of the duodenum 4 cm. below the ampulla of Vater, became so weak that it was unable to stand. The mouth was dry and the eyes were covered with a thick mucoid discharge. Muscle groups twitched irregularly throughout the body and there had been a loss of 17 per cent of body weight. Chlorides had fallen from 370 to 196 mg. per cent. Potassium, after

PROTOCOL 3

DUODENAL OBSTRUCTION BY SIMPLE LIGATION

Dog 201L, female; weight, 4.74 kilo. On Aug. 3, 1937, the duodenum was ligated 2 cm. distal to the ampulla of Vater with a piece of tape so placed that it did not disturb circulation.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|---|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 101.2 | 366 | 345 | 18.6 |
| 7 | Vomiting; slightly apathetic | 100.4 | 324 | 366 | 18.0 |
| 19 | Some vomiting; dry; looks quite well | 103.2 | 319 | 351 | 20.0 |
| 41 | Weak, but stands and wags tail; dry | 101.8 | 242 | | |
| 51 | Very weak, refuses to stand; scum over eyes; muscle twitch | 102.6 | | 314 | 30.0 |
| 52 | % weight loss, 13.5 Dead—Autopsy: purulent exudate throughout peritoneal cavity but peritoneum only slightly injected; ligature cut through bowel wall resulting in leakage; stomach and bowel collapsed; both lungs contained hemorrhagic areas | | | | |

an initial drop from 30.5 to 21.4 mg. per cent during the first 55 hours, had regained much of the loss but reached a maximum level of only 29 mg. per cent.

At this time the animal's death seemed imminent, but 24 hours later there was unmistakable evidence of improvement, which lasted about 48 hours. Then there developed a return of symptoms and again death seemed imminent. But at this time, 192 hours, 8 days following operation, something happened and from this time on the animal's condition constantly and rapidly improved. Subsequent exploratory operation showed that continuity of the duodenal lumen had been re-established by spontaneous anastomosis. With the beginning of improvement on the eighth day, the animal began to take water and there followed a sharp rise of sodium and a progressive but slower rise in chlorides. There was no change in the level of the potassium until the animal began to take food 96 hours later or on the twelfth day. It then progressively mounted.

Interestingly, there was no appreciable gain in weight during the first 7 days after the beginning of improvement and of ingestion of water. Before there was a gain in weight the serum sodium and chlorides had returned to nearly normal levels.

In Dog 401R analyses of sodium and potassium were made upon both serum and whole blood from samples drawn simultaneously. The sodium of both serum and whole blood decreased and, when the values were plotted, formed similar curves. The curves of potassium, however, were completely reversed. Potassium of the serum showed a progressive decrease and that of whole blood a progressive increase.

PROTOCOL 4

DUODENAL OBSTRUCTION BY SIMPLE LIGATION

Dog 101R, female; weight, 7.03 kilo. On July 27, 1937, the duodenum was ligated with a broad piece of tape, 4 cm. distal to the ampulla of Vater.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|--|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 101.0 | | 346 | 30.6 |
| 7 | Vomited several times; slightly apathetic | | 336 | 366 | 29.0 |
| 19 | Continued vomiting, dry but looks fairly well | 102.2 | 312 | 362 | 29.2 |
| 22 | Dry, weak; has taken no food and little water | | | 371 | 27.6 |
| 26 | No change | 101.6 | | 366 | 25.2 |
| 42 | Vomiting less; much weaker; mucopurulent scum over the eyes | 100.1 | 252 | 362 | 24.0 |
| 55 | Weak, tremulous, very gaunt | 100.0 | 221 | 332 | 21.4 |
| 74 | Sways when standing, staggers and falls | 100.4 | 223 | 312 | 26.6 |
| 90 | Unable to stand, cold, uninterested in surroundings; twitching | 100.0 | 209 | 317 | 26.6 |
| 105 | Nearly moribund; 21% weight loss | 100.0 | 214 | 321 | 21.6 |
| 139 | Spontaneous anastomosis and release of obstruction; much improved; stands, wags tail, drinks water | 100.6 | 209 | 324 | 19.0 |
| 176 | Condition unchanged | 100.4 | 196 | 293 | 20.4 |
| 188 | Relapse, nearly moribund | 100.2 | 196 | 287 | 14.6 |
| 234 | Much improved, appears well but weak, flanks filled out; taking food | 101.4 | 206 | 331 | 17.2 |
| 288 | Continued improvement; appears quite well | 102.2 | 227 | 348 | 18.0 |
| 360 | Jumps about, appears well | | 309 | 379 | 23.2 |
| 405 | | | 327 | 375 | 23.6 |
| 502 | Regained preoperative weight | | 332 | 380 | 24.7 |
| 574 | Continued normal appearance | 102.2 | 337 | 325 | 27.4 |

Exploratory operation showed that ligature around bowel had cut through and a spontaneous anastomosis had developed. Apparently this took place simultaneously with recovery from moribund state. As the dog began to take water, the chlorides and sodium dropped slightly, possibly from blood dilution, and then increased rapidly.

From these findings, it would appear that the relative content of potassium in serum and in whole blood does not remain constant and that determinations made upon whole blood do not indicate the changes which take place in serum potassium.

PROTOCOL 5

DUODENAL OBSTRUCTION BY SIMPLE LIGATION

Dog 401R, female; weight, 7.3 kilo. Aug. 24, 1937, the duodenum was ligated 5 cm. distal to the ampulla of Vater with tape.

| HOURS POST- OPERATIVELY | REMARKS | RECTAL TEMPERATURE | CHLORIDES | | SODIUM | | POTASSIUM | |
|----------------------------|--|-----------------------|-----------|-------------|--------|-------------|-----------|-------------|
| | | | SERUM | WHOLE BLOOD | SERUM | WHOLE BLOOD | SERUM | WHOLE BLOOD |
| 24 | Preoperative Vomited several times; weak and dry Less vomiting; listless; wobbles when standing Scum over eyes; generalized twitching; very weak No definite change; possibly stronger | 101.2 | 331 | | 386 | 245 | 30.2 | 24.8 |
| 48 | | 102.6 | 293 | | 361 | | 23.4 | |
| 76 | | 101.9 | 238 | | 360 | 198 | 21.8 | 28.9 |
| 90 | | 101.5 | 221 | | 326 | | 21.8 | |
| | | 100.8 | 244 | | 365 | 219 | 20.8 | 26.5 |

From this time on the animal improved and rapidly regained normal health. At a subsequent post-mortem examination, it was found that a spontaneous anastomosis had been established around the point of obstruction

3. *Obstruction With Strangulation.*—In 2 dogs the duodenum below the ampulla of Vater and including a small upper segment of jejunum were strangulated by encircling the loop with a piece of tape which was tied with tension sufficient to cause obstruction of the bowel and of venous return but not of the arterial blood supply. The loops were 20 cm. and 12 cm. in length. The dog with the longer loop died in 18 hours, while the one with the short loop survived 27 hours. Each dog lost approximately 10 per cent of its body weight and showed no significant alteration of blood chemistry. The chlorides dropped only slightly and the sodium in each instance, after a transient, abrupt elevation, returned to the normal preoperative levels. Potassium in the dog with the long loop remained unchanged; in the other one it

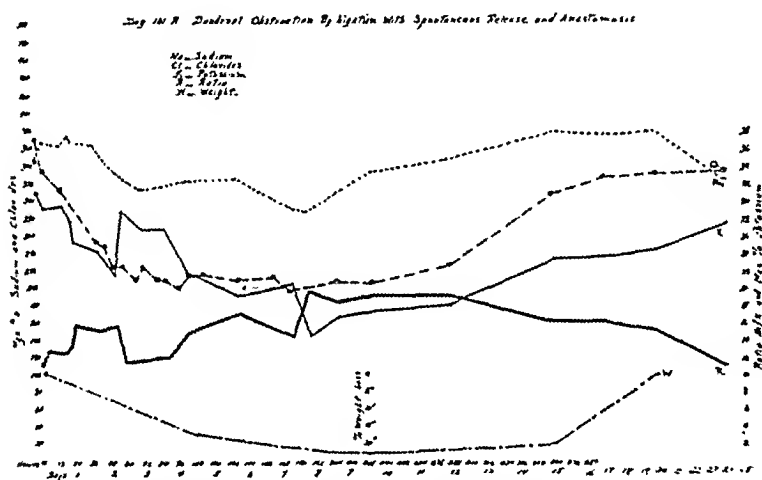


FIG. 7.—Duodenal obstruction with recovery. After becoming moribund, this animal recovered. The ligature had cut through and an end-to-end anastomosis had been established spontaneously. Note that the serum potassium as well as the sodium and chlorides decreased progressively until the animal began to recover. After taking water on the sixth day, there was a sudden drop to very low levels, presumably the result of dilution. Note that the potassium increased more slowly than sodium and chlorides during recovery.

decreased from a preoperative level of 25 to 20 mg. per cent. (See Fig. 8A and B and Protocols 6 and 7.)

It should be noted that in these animals in which strangulation was superimposed upon obstruction and in which death occurred early the serum potassium never became elevated above the normal pre-operative levels.

DUODENAL FISTULAS

In 2 dogs the duodenum was divided, except for a small bridge of tissue at the mesenteric border, approximately 8 cm. below the ampulla of Vater, and the free margins of both ends were sutured to the skin. Lost through the fistula were not only all of the gastric, biliary, pan-

PROTOCOL 6

DUODENAL STRANGULATION

Dog 102R, female; weight, 5.65 kilo. On July 26, 1937, a loop of duodenum, 20 cm. long and about 10 cm. below the ampulla of Vater, was strangulated by an encircling ligature of tape.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|--|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 97.8 | | 398 | 28.0 |
| 6 | Vomited several times; weak and listless | 96.6 | 328 | 436 | 28.8 |
| 18 | Dry, cold, almost moribund; scum over eyes; both local and general twitchings | 96.0 | 337 | 398 | 28.4 |
| 18½ | Death: weight, 5 kilo., a loss of 10 per cent of body weight. Autopsy: abdomen slightly distended and contained much thick bloody fluid; no peritonitis (no exudate or injection of peritoneum); stomach and duodenum distended and below obstruction bowel collapsed; liver swollen; heart and lungs normal | | | | |

creatic, and duodenal secretions, but also all water and food ingested. These animals did not vomit and apparently at no time was there retention of secretions. Also, there was no ante-mortem or post-mortem evidence of any physiologic disturbance other than the loss of secretions and yet these dogs died in less than 64 hours, lost from 18 to 20 per cent of their body weights, and showed higher elevations of serum potassium than did the animals with obstruction. In both dogs the potassium, after a preliminary drop, increased to 39.5 mg.

PROTOCOL 7

DUODENAL STRANGULATION

Dog 202L, male; weight, 5.0 kilo. Aug. 3, 1937, a 12 cm. loop of duodenum was strangulated with a broad band of tape, the proximal end being 5 cm. distal to the ampulla of Vater.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|--|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 101.0 | 334 | 331 | 25.2 |
| 7 | Vomited several times; slightly listless | 100.2 | 330 | 382 | 20.6 |
| 13 | Same | 99.0 | 345 | 361 | 21.2 |
| 16 | Less vomiting; weaker | 100.8 | 326 | 366 | 22.0 |
| 20 | Dry, eyes covered with scum | 100.6 | 324 | 330 | 20.1 |
| 25 | Much weaker; some muscle twitching | 102.6 | 306 | 339 | 20.2 |
| 28 | Refuses to stand, irregular twitchings of muscles | 104.8 | 308 | 336 | 21.2 |
| 31 | Death—Autopsy: much bloody fluid in peritoneal cavity; strangulated loop of bowel black and surrounded by omentum; loop of bowel distended and filled with foul-smelling black bloody fluid; general peritoneal surfaces not inflamed (no peritonitis); stomach and duodenum proximal to obstruction moderately dilated, distal intestines collapsed | | | | |

per cent from preoperative levels of 26.8 and 22.2 mg. per cent. The chlorides decreased progressively to very low levels as in the ob-

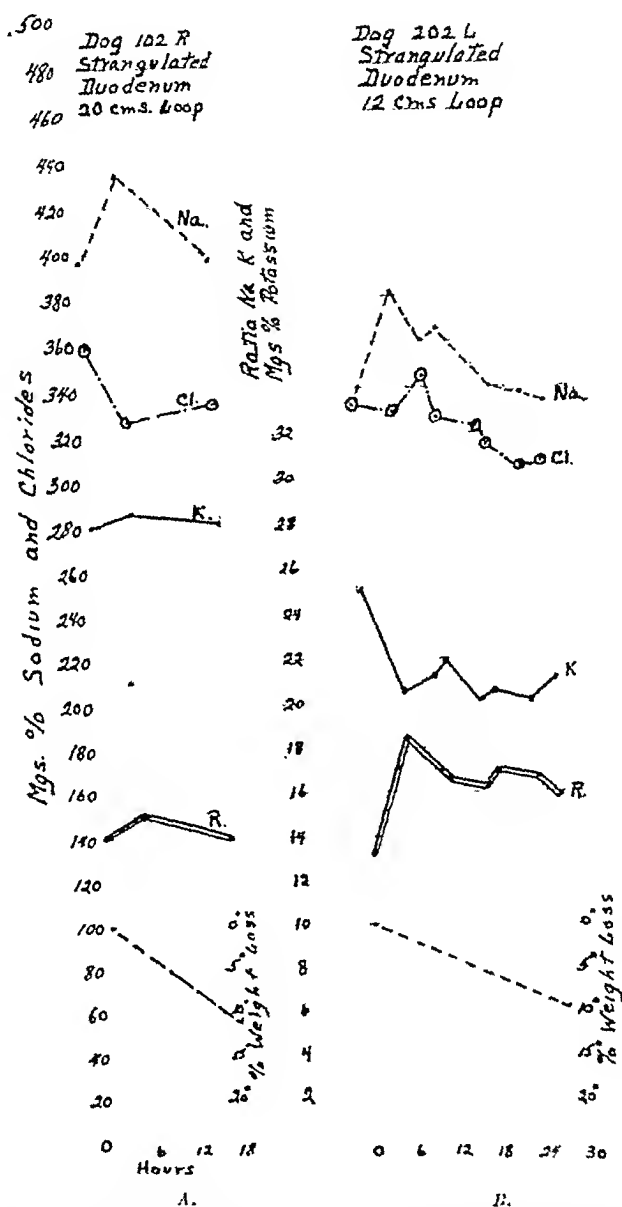


Fig. 8.A and B.—Duodenal obstruction with strangulation. Despite profound toxemia with early death, there developed no appreciable alterations in the levels of either sodium, potassium or chlorides.

structed animals, and sodium showed no consistent or significant change. The sodium-potassium ratios roughly followed inversely the fluctuations of potassium. See Fig. 9.A and B and Protocols 8 and 9.

PROTOCOL 8

DUODENAL FISTULA

Dog 104R1, male; weight, 6.46 kilo. July 26, 1937, the duodenum, approximately 5 cm. below the ampulla of Vater, was divided except for a small connecting bridge at the mesenteric border. The edges of the free ends were sutured to the skin.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|---|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 100.8 | | 332 | 26.8 |
| 6 | Fistulas discharging clear fluid; normally active | 102.0 | 327 | 357 | 23.2 |
| 18 | Some skin irritation; drinks water, looks well | 102.4 | 317 | 357 | 26.4 |
| 21 | Copious drainage; condition good | | | 356 | 22.2 |
| 26 | No change | 102.6 | | 366 | 25.2 |
| 42 | Dry, weaker, seum over eyes; skin digested | 102.0 | | 303 | 29.0 |
| 50 | Much weaker; twitches slightly | 101.1 | 247 | 352 | 39.6 |
| 60 | Gaunt, refuses to get up; local and general twitchings | 100.1 | 209 | 316 | 31.6 |
| 62 | Death—Autopsy: weight, 5.26 kilo., a loss of 18 per cent of body weight; tissues were dry, the skin around fistulas digested, peritoneal cavity normal, the stomach and bowel collapsed, the right lung hemorrhagic, the left lung and the heart normal | | | | |

PROTOCOL 9

DUODENAL FISTULA

Dog 203R, male; weight, 6.1 kilo. Aug. 3, 1937, the duodenum was divided 7 cm. distal to the ampulla of Vater and the edges of both ends were sutured to the skin.

| HOURS POSTOPERATIVELY | REMARKS | RECTAL TEMPERATURE | SERUM CHLORIDES | SERUM SODIUM | SERUM POTASSIUM |
|-----------------------|---|--------------------|-----------------|--------------|-----------------|
| | Preoperative | 101.0 | 336 | 376 | 23.2 |
| 6 | Drainage of some clear fluid from fistula; appears well | 100.4 | 312 | 356 | 22.4 |
| 18 | Copious discharge from fistula; takes water; appears weak | 103.2 | 281 | 340 | 18.2 |
| 30 | Irritation and beginning digestion of skin about fistula; weaker | 102.4 | 269 | 336 | 26.8 |
| 34 | Same | 101.9 | 263 | 347 | 25.6 |
| 40 | Skin about fistula raw; dry, eye seum; standing is an effort | 100.8 | 248 | 345 | 29.6 |
| 46 | Irregular twitching of muscle groups and generalized trembling | 101.0 | 248 | 356 | 33.8 |
| 50 | Cold, moribund | 104.4 | 254 | 321 | 39.6 |
| 50½ | Death—Autopsy: weight, 4.9 kilo., a loss of nearly 20 per cent of body weight; tissues dry; no peritonitis; stomach and bowel collapsed; both lungs contained large hemorrhagic areas; heart normal | | | | |

DISCUSSION

In common with corticoadrenal deficiency states, the conditions which have been the subjects of this investigation, traumatic shock, the shock of hyperpyrexia, high intestinal obstruction, and duodenal fistulas are characterized by profound prostration and by the amelioration of the prostration by the administration of sodium chlorides either alone or with water. This suggested the possibility of a com-

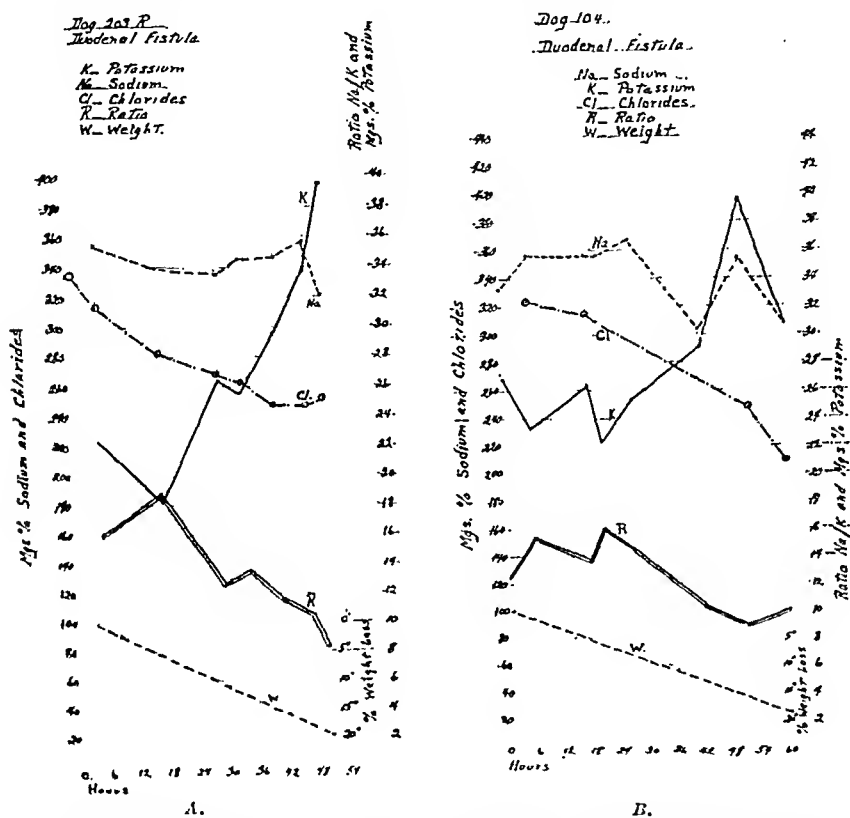


FIG. 9A and B.—Duodenal fistulas. The duodenum was divided and both ends sutured to the skin so that all ingested food and fluids and all secretions proximal to the level of division were lost through the fistulas. Note the big decrease in chlorides and increase in potassium.

mon biochemical factor. Kendall has shown that in corticoadrenal deficiency states there exists an abnormal ratio between the sodium and potassium of the blood, a relative decrease of sodium and increase of potassium.

Because the ratio of sodium to potassium showed no constant or significant alteration in our experimental animals, it would appear that this factor contributed little or nothing to the production of the abnormal manifestations and death.

In the animals subjected to a progressive, lethal hyperpyrexia, there developed constantly a slight, relative increase of potassium without alteration of sodium. The failure to lose sodium and chlorides as occurs in man can be explained by the fact that the dog has no sweat glands. Therefore, the biochemical changes which take place under these circumstances are not comparable in the two species.

In an investigation of high intestinal obstruction in cats, Seudder, Zwemer, and Truszkowski constantly found an elevation of potassium in whole blood and stated that the potassium accumulated in sufficient concentration in the blood to produce lethal potassium poisoning. They suggest that potassium is the toxic factor which produces symptoms and death in high intestinal obstruction.

In striking variance with their results are the results of our experiments. True, potassium did become elevated considerably above the preoperative levels in approximately one-half of the obstructed animals in our series, but, if potassium is the toxic factor, it should become elevated in all instances of obstruction with toxemia. In 2 dogs which became moribund and then recovered, the potassium never became elevated above the normal preoperative levels. Likewise, in the two dogs with strangulated loops of bowel in which the toxemia was most profound and death occurred very early, the potassium never became elevated above the normal preoperative levels. It is also of interest that the highest rises of potassium occurred in the two dogs with duodenal fistulas. In these animals there was no obstruction, merely a total loss of fluids and their solutes. They did not vomit and were able to take fluids. They lived longer than the obstructed animals but died with the same clinical manifestations. Also, with one exception, they showed greater weight losses than the obstructed dogs.

The discrepancy between our findings and those obtained by Seudder and others may be explained by the difference in species of animals used or by the fact that their determinations were made upon whole blood and ours upon blood serum. To determine this point, analyses of sodium and potassium were made upon both serum and whole blood drawn simultaneously from one obstructed dog. The results were in no way comparable. As shown in Fig. 6B, there was much less sodium in whole blood than in serum and with obstruction the potassium in whole blood increased slightly while that in serum decreased greatly. Consequently, if the toxicity of a substance depends upon its concentration in serum it cannot be assayed in the dog by determinations made upon whole blood.

Of interest was the relative duration of life; this in order from longest duration is as follows: those with fistulas, 64 hours; pyloric obstruction, 52 hours; duodenal obstruction, 42 hours; strangulated short duodenal loop, 27 hours; and strangulated long duodenal loop,

18 hours. Consistent with other observers, the duration of life in animals with strangulated loops of bowel is inversely proportional to the length of the loops.

CONCLUSIONS

1. Both adrenalin and inhaled ether caused precipitous but transient drops in serum potassium but no appreciable change in serum sodium and chlorides.

2. In traumatic shock there was no consistent alteration of serum sodium, potassium, or chlorides.

3. Hyperthermic shock was associated with a marked rise of serum potassium, rising to levels of 30 to 50 per cent above the normal pre-operative levels. Serum sodium and chlorides unchanged. Consequently the sodium-potassium ratios varied inversely with the potassium. As the dogs have no sweat glands, there is no loss of fluids or salt through the skin as occurs in man. This, no doubt, accounts for the difference in the response of sodium and chlorides to hyperpyrexia in the two species.

4. In high intestinal obstruction there was no consistent change in serum potassium or sodium, but there was, except in one instance, a large fall in chlorides. There was no evidence in our experiments that potassium contributed to the production of symptoms and of death in high intestinal obstruction or in duodenal fistulas.

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Of interest was the relative duration of life; this in order from longest duration is as follows: those with fistulas, 64 hours; pyloric obstruction, 52 hours; duodenal obstruction, 42 hours; strangulated short duodenal loop, 27 hours; and strangulated long duodenal loop,

packed without storing fluid. Size No. 2, both plain and chromic, was used throughout. The ligatures were washed in water for twenty-four hours and transferred to the suspensions of bacteria (described below). After incubation in the suspensions, the ligatures were removed to sterile tubes and desiccated over CaCl_2 at reduced pressure in the ice-box. The time of desiccation varied from one to three weeks.

Suspensions of Organisms.—The *Cl. sporogenes* and *B. subtilis* were stock strains from this laboratory. The *Staph. albus* culture was encountered during the sterility test. Aerobic organisms were grown on nutrient agar in Kolle flasks and the growth washed off with sterile water. Anaerobic cultures were grown in beef-heart medium, the growth collected by centrifugation and resuspended in sterile water. Incubation of cultures was sufficiently long to ensure good growth and spore formation by those organisms which produced spores. When viable counts were made of the suspensions prepared by this method, the agar plate method was used.

Storing Fluids.—Ninety-five per cent alcohol (ethyl alcohol denatured with 5 per cent methyl alcohol) was sterilized by Berkefeld filtration. Toluol was sterilized by heat. These fluids were added to the tubes containing the desiccated ligatures, care being taken to ensure that organisms did not survive on the sides of the tubes above the level of the fluid. Tubes kept for long time intervals were sealed.

Experimentally contaminated ligatures subjected to heating were treated at sterilizing temperatures in the absence of water.

After exposure to the test conditions, the ligatures were cultured by the method of Meleney and Chatfield.¹ Bacteriological tests were made to determine the identity of the organisms cultured.

RESULTS

None of the organisms survived heating in the dehydrated state. Ten ligatures contaminated with each of the test organisms were treated in this manner. The organisms, therefore, apparently acquired no unusual resistance to heat sterilization by the dehydration process.

In a preliminary experiment it was found that the sporulating organisms, *B. subtilis* and *Cl. sporogenes*, could survive exposure to both alcohol and toluol for at least seventeen days. In later experiments, Table I, *B. subtilis* survived in each of these solutions for six months. *Cl. sporogenes* survived well in alcohol for fifty-six days, and growth was obtained from one of nine ligatures tested after six months. It therefore appeared doubtful that the strain under consideration would have been viable after a much longer period of exposure. In toluol growth of *Cl. sporogenes* was obtained only from three of five ligatures tested at fifty-six days, all the other cultures being negative in the later experiments. In view of the results of the earlier experiments these are somewhat difficult to interpret. In view of the inconsistency of the

THE SURVIVAL OF CLOSTRIDIUM SPOROGENES, BACILLUS SUBTILIS, AND STAPHYLOCOCCUS ALBUS ON SURGICAL (CATGUT) LIGATURES

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THE adoption of more rigid and uniform procedures for the sterility testing of surgical ligatures has raised the question of the ability of different types of bacteria to survive on ligatures. The necessary handling of ligatures during the sterility test involves a risk of occasional contamination, and it therefore becomes important to know whether a particular type could have been present on the ligature or may have been introduced through errors in technique.

Consideration of this problem led us to the conclusion that, irrespective of the sterilizing process to which the ligature has been subjected, an organism cultured at the time of the sterility test in order to be significant of contamination must be capable of remaining viable in the fluid in which the ligature is stored. The storing fluids used by manufacturers differ greatly. However, they may in general be classified in two groups of chemical compounds: the aliphatic alcohols used as storing fluids for nonboilable ligatures, and benzene and related compounds used for boilable ligatures. Since the collagen of the ligature is chemically altered in aqueous media and the ligature must, therefore, be subjected to a process of dehydration during manufacture, it appeared to us that bacteria present on them must also be dehydrated, and that viable organisms encountered in the sterility test must have survived in this state in order to have been present on the ligature. The usual figures given for the resistance of aqueous suspensions of bacteria to chemical agents could not be directly applied in this case, due to the difference in suspending medium.

We have determined the resistance of *B. subtilis*, *Cl. sporogenes*, and *Staph. albus*, when dried on ligatures, to denatured alcohol and toluol. These organisms were selected as representative of aerobic and anaerobic sporulating rods and nonsporulating organisms respectively. They also represent types encountered in the culture of ligatures. Alcohol and toluol were chosen as representative of the two main classes of storing fluids in common use.

MATERIALS AND METHODS

Ligatures.—Heat-sterilized ligatures for these experiments were obtained from the laboratories of Armour and Company. These were

CONCLUSIONS

B. subtilis when dried on surgical ligatures was found to survive exposure to either toluol or alcohol for at least six months.

Cl. sporogenes survived in alcohol for six months, but showed only slight resistance to the action of toluol.

The experiments in general, however, indicate that any sporulating organism encountered in the routine sterility test might have been present on the ligature and should be considered as significant of possible contamination of the ligature, unless resampling indicates that they are sterile.

Staph. albus did not survive exposure to either toluol or alcohol for sufficiently long periods of time to be of significance to the contamination of ligatures, and on the basis of these experiments we feel that, when encountered in the routine sterility test, it indicates error in technique rather than contamination of the ligature.

REFERENCE

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TABLE I

SURVIVAL OF ORGANISMS IN TOLUOL AND ALCOHOL WHEN DRIED ON LIGATURES

| CULTURE | TIME EXPOSED | TEST SOLUTION | | | | CONTROLS | |
|-----------------------|-----------------|---------------|--------|--------|--------|----------|--------|
| | | ALCOHOL | | TOLUOL | | | |
| LIGATURES | | TESTED | GROWTH | TESTED | GROWTH | TESTED | GROWTH |
| <i>Cl. sporogenes</i> | 7 days | 5 | 5 | 5 | 0 | 2 | 2 |
| | 14 days | 5 | 2 | 5 | 0 | 3 | 0 |
| | 21 days | 5 | 5 | 5 | 0 | 3 | 3 |
| | 28 days | 5 | 3 | 5 | 0 | 3 | 3 |
| | 56 days | 5 | 5 | 5 | 3 | 2 | 2 |
| | 6 mo. | 9 | 1 | 10 | 0 | 5 | 5 |
| | Total | 34 | 21 | 35 | 3 | 18 | 15 |
| <i>B. subtilis</i> | 7 days | 4 | 4 | 5 | 5 | 4 | 4 |
| | 14 days | 5 | 5 | 5 | 5 | 4 | 4 |
| | 21 days | 5 | 5 | 5 | 5 | 3 | 3 |
| | 28 days | 5 | 5 | 5 | 5 | 3 | 3 |
| | 92 days | 5 | 5 | 5 | 5 | 3 | 3 |
| | 6 mo. | 10 | 10 | 7 | 7 | 7 | 7 |
| | Total | 34 | 34 | 32 | 32 | 24 | 24 |
| <i>Staph. albus</i> | 5 min. | 10 | 10 | 22 | 0 | | |
| | 10 min. | 10 | 10 | 22 | 0 | | |
| | 15 min. | 10 | 10 | 22 | 0 | | |
| | 20 min. | 10* | 10 | 22 | 0 | 32 | 13 |
| | Total | 40 | 40 | 88 | 0 | 32 | 13 |

*Ligatures were tested at intervals up to twenty-four hours without obtaining further growth.

positive result obtained at fifty-six days in the toluol series of "sporogenes" ligatures, it would seem that this positive culture was due to some technical error. We do not mean to imply, however, that any sporulating organism encountered during the routine examination of ligatures for sterility should be disregarded. The results as a whole nullify such an implication, and we feel that the observation that *Cl. sporogenes* does not show the same capacity for surviving under the conditions of these experiments as does *B. subtilis* has no practical bearing on the present problem.

Staphylococci were found to survive very poorly the drying conditions of these experiments. Despite the fact that suspensions of approximately 1×10^{13} viable organisms per cubic centimeter were used to contaminate the ligatures, they were found to be sterile upon removal from the desiccator in several experiments. In preliminary experiments with these organisms both moist and dehydrated ligatures were used. The former were found to be sterile after exposure for ten minutes, and the latter after exposure for fifteen minutes to both toluol and alcohol. These were the shortest time intervals tested in this experiment. The results of later experiments are given in Table I. It is apparent from the results of these experiments that this organism could not survive exposure to the test solutions.

Whether the ligatures were chromic or plain did not affect the results of these experiments.

CONCLUSIONS

B. subtilis when dried on surgical ligatures was found to survive exposure to either toluol or alcohol for at least six months.

Cl. sporogenes survived in alcohol for six months, but showed only slight resistance to the action of toluol.

The experiments in general, however, indicate that any sporulating organism encountered in the routine sterility test might have been present on the ligature and should be considered as significant of possible contamination of the ligature, unless resampling indicates that they are sterile.

Staph. albus did not survive exposure to either toluol or alcohol for sufficiently long periods of time to be of significance to the contamination of ligatures, and on the basis of these experiments we feel that, when encountered in the routine sterility test, it indicates error in technique rather than contamination of the ligature.

REFERENCE

1. Meleney, F. L., and Chatfield, Mable: Surg., Gynec. & Obst. 52: 430, 1931.

TREATMENT OF THE UNDESCENDED TESTIS: WITH SPECIAL REFERENCE TO THERAPY WITH HORMONES*

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UNDESCENDED testis is one of the more common genitourinary anomalies with which the surgeon must deal. It occurs in from 0.1 per cent (Marshall) to 0.12 per cent (Monod and Terrillon) of males. The statistics of the Austrian army show that 2.2 cases of undescended testis occurred in every 1,000 men drafted for military service (Ziebert). According to the War Department's medical records with the World War, there were 3.1 cases of ectopy for every thousand men examined. Eeles found 2 per cent of undescended testes in 48,000 hernias. Bevan, Coley, and Wangenstein put the incidence of retained gonad at 1 in 500 men.

Incomplete descent is more common on the right than on the left side. From the statistics of Berger, Hofstatter, and others, the incidence of right-sided maldescent is equal to that of double and left-sided retention combined. In 20 per cent of undescended testes the deformity is bilateral (Wangensteen).

Pain, torsion, hernia, and malignancy are the most common complications of undescended testis. However, except for hernia, most patients with undescended testis do not present themselves for treatment because of complications. Some are conscious of the aberrant position of the ectopic gland. Others are concerned about the fertility of the retained gonad. Not a few, wishing to avoid a surgical operation, ask about the chance of spontaneous descent or the results of "injection" (endocrine) therapy.

The surgeon is confronted with the problem of selecting the best treatment for these patients. If the treatment is to be surgical, should the retained testis be removed, because of the danger of malignancy or because of its questionable function, or should it be serotally fixed? If the testis is anchored in the scrotum, is the result to be considered purely cosmetic or will the function of the organ be improved? Although orchiopexy has been performed for more than a century, it is surprising how few investigators have inquired if the undescended gonad had any function, or, if such a function existed, whether it could be maintained or improved by serotal fixation. From a review of the literature, it seems established that in most cases the undescended

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testis may have an internal secretion and occasionally may possess an external secretion sufficient for potential, if not absolute, fertility. It is estimated that 10 per cent of untreated human cryptorchids remain fertile (Uffreduzzi). It has been proved clinically that as high as 82 per cent of patients treated by orchiopexy have active spermatozoa in the semen (MacCollum). Placing the slightly atrophic or immature retained testis of man and the pig in the scrotum has been shown experimentally to allow a mature germinal epithelium to be produced (Wangensteen). The degree of maturity after scrotal fixation is never as great as that seen in the case of the experimentally produced cryptorchid so treated. However, clinically and experimentally the value of scrotal fixation for testicular development has been proved beyond doubt.

There is a diversity of opinion among surgeons as to the best treatment for the undescended testis. Some believe that the ectopic gland is potentially malignant and should be removed. Others believe that, if left alone, most of these retained gonads will descend spontaneously. Recently the reports of some investigators indicated that the results from hormonal therapy are equally as good as, if not superior to, those obtained by surgical treatment (orchiopexy). In formulating a rational plan of treatment of the undescended testis, one is influenced by the number and type of cases he has seen, his surgical experience and that of his associates, and the type of case that receives hormonal therapy.

The questions of malignancy of the testis, spontaneous testicular descent, and surgical technique are beyond the scope of this paper and are discussed in detail elsewhere. In review, however, it may be said that the undescended testis should not be considered a precancerous lesion, as only about 2 per cent of such organs develop tumors (Hinman). Spontaneous descent is a rare occurrence in our experience; the policy of "watchful expectancy" after puberty is not justified, knowing from experimental studies how atrophic the ectopic testis becomes when deprived of its scrotal environment. Wangenstein has described a modification of the Keetley-Torek operation which has given uniformly good results in the surgical treatment of this condition. The only change in technique of the operation since its initial description has been the substitution of silk for catgut sutures in performing the scrotal-erural anastomosis and the hernial repair.

For the past four years, at the University of Minnesota Hospitals, some cases of undescended testis have been treated by hormones. Schapiro in 1930 reported genital growth and testicular descent by anterior pituitary-like substance in boys and young men with hypogonadism and cryptorchidism. Since then there have been several series in the literature of undescended testis treated by this material. Thomp-

son and others and Cramer recently have summarized the results of most investigators; in over 70 per cent of cases descent of the retained gonad has occurred. How critically some of the cases were observed may be questioned when in one series the testis was reported to have descended within three hours after treatment (Harris). About one-half of the cases showed signs of hypopituitarism of adipogenitodystrophies and received other therapy besides pituitary extract (thyroid extracts, diet, etc.). From a summary of published data, the original position of the gonad successfully brought into the scrotum by anterior pituitary-like substance was as follows: upper scrotum, intra-abdominal, and inguinal in the order named (Thompson and others).

Kunstadter, Robins, Schapiro, and Goldman and Stern believe that the administration of extracts of pregnancy urine is indicated in hypopituitarism of the male characterized by genital underdevelopment. However, the clinical diagnosis of pituitary or other endocrine dyscrasia always is subject to considerable variation in interpretation. Hess, Kunstadter, and Saphir believe that, if cases of cryptorchidism could be studied with more objective criteria, a more rational therapy could be instituted. It is known that whenever gonadal function is diminished or absent, as in adult hypogonadism, the menopause, or castration (Evans, Engle, and Smith), there is an excessive excretion of the gonadotropic hormone, presumably of pituitary origin. Katzman and Doisy have shown that the urine of normal children contains little or no gonadotropic hormone. Hess and co-workers reasoned that, since in the castrated person or in cryptorchid boys the gonadotropic hormone is presumably of pituitary origin, it seemed logical to conclude that the presence of gonadotropic substance in the urine of cryptorchids indicates an active anterior pituitary gland as to gonadotropic function. The appearance of the hormone in the urine may be due to insufficient activity of the gonad which failed to modify the hormone or remove it from the blood. On the other hand, the occurrence of cryptorchidism with an absence of gonadotropic hormone from the urine may be interpreted to mean either the presence of a primary pituitary dysfunction or the presence of a functionally active bilateral undescended testis, or at least one functionally active testis.

Accordingly Hess and others determined in a semiquantitative manner the excretion of gonadotropic substance in the urine of cryptorchid boys before and after treatment with gonadotropic substance. Nine of thirteen of their cases of cryptorchidism responded to the use of anterior pituitary-like factor by descent of the testis and disappearance of the hormone from the urine. They believe that, in the absence of mechanical obstruction to descent, the best results after using anterior pituitary-like substance are obtained in those cases of undescended testis that have gonadotropic hormone in the urine which disappears after treatment.

Hardy, Bigler, and Scott have reported one of the largest series to date of cryptorchids treated by hormonal therapy. In one group 32 boys with 40 undescended testes were treated with gonadotropic principle of the anterior pituitary gland. In 26 cases the testicles remained unchanged in location; in 4 there was partial descent and in 10, or 25 per cent, there was complete descent. After discontinuing treatment, however, only 7, or 18 per cent, remained descended. In another group antuitrin-S* was used in the treatment of 23 patients with 31 undescended testicles. No change was observed in 12 testicles; 4 descended partially, and 15, or 48 per cent, descended completely. However, only 14, or 45 per cent, remained descended upon further observation. Both extracts were used in the treatment of 16 boys with 20 undescended testicles, and in 9, or 45 per cent, there was complete descent, which was permanent in 5, or 25 per cent, of the cases. They found that descent of the testicle usually begins to take place before 4,000 rat units of gonadotropic substance have been given.

Undoubtedly, in the literature more prominence has been given to the successes than the failures. Few contraindications to therapy with gonadotropic hormones are recognized and the method is too recent to permit investigation into the possibility of late complications. Thompson, Bevan, and others, obtained descent in 4 inguinally retained testes in 21 instances of cryptorchidism (19 per cent). Mimpres, who obtained descent in only 6 of 20 cases of undescended testis so treated, believes that anterior pituitary-like substance should be used chiefly in bilateral cryptorchids with subnormal genital development. Cabot has referred to the possibility of late atrophy of the testes and Cole has produced atrophy of the tubules of the testes by high doses. Goldman and Stern have commented on the possible development of precocious sexual maturity, and for this reason consider 9 years as the earliest age at which treatment with gonadotropic hormones should be started. In this clinic also there is some hesitancy in using anterior pituitary-like substance in very young children, but Dorff and Aberle and Jenkins have used this hormone in children about 3 years of age with no untoward results. Geschiekter and others found that extracts of the urine of pregnancy in young male monkeys produced hypertrophy of the prostate and enlargement of the breasts. However, from a survey of the available literature and the experience at this clinic, the danger of most of the above complications would seem more theoretical than real.

THE UNIVERSITY OF MINNESOTA HOSPITAL SERIES

The results at the University of Minnesota Hospitals using anterior pituitary-like substances in the treatment of retained testis are summarized below. Four products have been tried: antuitrin-S (Parke-

*Anterior pituitary-like substance from pregnancy urine (Parke-Davis).

Davis), follutein (Squibb), prephysin (Chappell), and A. P. L. (Ayerst). The last three products have been used in only a few cases.

A. Antuitrin-S.—It has been our practice to inject 1 c.c. (100 rat units) of antuitrin-S daily into the subcutaneous tissue of the thighs for thirty days (3,000 units). If no results are obtained before this time, the patient is then observed every month for three months and then every three months. Some of the cases in which no results were obtained have been followed for two years.

Thirty patients with 36 undescended testes have been treated to date with antuitrin-S (Parke-Davis) in this clinic. The ages of the patients varied from 4 to 24 years. The testes were bilaterally retained in 6 instances. Two of the bilateral cryptorchids also had hypospadias and there was a suggestion of Fröhlich's syndrome in 1 bilateral and 1 inguinally retained case. Five patients responded to the treatment by degrees of descent of the testis into the scrotum. While descent of the retained gonad was complete in 3 cases, it was only to a high scrotal position in the other 2 cases (U. H. No. 648741 and No. 630358). Both of these patients were older and later submitted to orchiopexy. One of these patients (U. H. No. 648741) received a total of 6,000 units over a period of two months. It is interesting that no spermatozoa were seen in either the biopsy or smear of the testis when the patient later submitted to orchiopexy. Also the microscopic section of the testis showed the usual atrophic appearance (HO-37-574).

No untoward results have ever been observed over a period of two years following the use of antuitrin-S in this clinic. There was suprapubic edema in 3 cases which disappeared after treatment and 1 patient complained of swelling in the left breast which clinically was thought to be a fibrous mastitis. In none of the cases was there a demonstrable increase in the size of the penis. The testes of the successfully treated cases often enlarged; we could not be sure that there was any change in size of the testes in the unsuccessfully treated cases. The scrotum of one boy (see chart, U. H. No. 694590) became red and slightly edematous after 2,000 units of antuitrin-S had been administered. In none of the cases was there premature appearance or increase in the amount of pubic, axillary, or facial hair. Five patients noticed increased frequency of erections.

B. Follutein.—Two patients, aged 21 and 23 years, were treated by follutein (Squibb) for undescended testes. The testes were bilaterally retained (inguinal) in 1 case, and inguinally arrested on the right side in the other. One cubic centimeter of follutein (125 c.c.) was injected daily for 10 days into the subcutaneous tissue of the thigh (1,250 units). No improvement was noted following this therapy; the patients were observed for a period of one year.

C. *Prephysin*.—Three patients, aged 2, 7, and 11 years, were treated with prephysin (Chappell). The undescended testes were unilateral and inguinally retained in all 3 cases. The 2 younger boys were brothers. Prephysin contains the follicle-stimulating principle of the pituitary gland, including small amounts of luteinizing factor. It differs from antuitrin-S and follutein in that it is extracted from the pituitary gland itself and not from pregnancy urine as the latter two are. One-half of one cubic centimeter of prephysin (1 c.c. is equivalent to 25 units) was injected daily for four days into the subcutaneous tissue of the thighs of these 3 boys. No descent of the testis was observed in any of these cases over a period of nine months.

D. A. P. L. (*Anterior Pituitary-Like Substance*) (*Ayerst*).—Four patients have been treated to date with this hormone, which is extracted from placental tissue. The special strength solution, 500 units per cubic centimeter, has been used in doses of $\frac{1}{2}$ c.c. every other day until fifteen injections have been given. Three patients with unilateral, inguinal testes have been treated with this substance and observed less than five months. No beneficial results have been noted to date. However, in the fourth patient, a boy 9 years old, with bilateral inguinal testes, complete descent of both testes occurred after the ninth injection.

Thus, in summary, of 36 patients with undescended testes who were treated by gonadotropic substances and followed six months or longer, degrees of descent were noted in 6 (16 per cent). In 4 descent was complete. It is possible that the dosage and period of injection of anterior pituitary-like substances in these cases were not adequate, but these factors are comparable to those reported in the successfully treated cases in the literature (Hardy, Bigler and Scott, Cramer).

AN EVALUATION OF THE TREATMENT OF ECTOPIC TESTIS BY GONADOTROPIC SUBSTANCE

Rubinstein has summarized the current concept regarding hormonal therapy in the treatment of undescended testis in the following statement: "The water-soluble fraction of pregnancy urine seems to produce testicular descent only if the pituitary gland is sexually underdeveloped. It then leads predominately to a stimulation of the interstitial cells of the testicle and may result in descent when a mechanical block does not exist."

In the cases of cryptorchidism which have been operated upon at the University of Minnesota Hospitals, nearly all have shown evidence of mechanical causes for arrest of descent. The testis was often lodged in pockets or bound down by adhesions to such extent that it was with great difficulty that they were freed or the spermatic cord lengthened sufficiently by loosening adhesions. It is almost inconceivable how one could bring such testes into the scrotum without surgical measures.

MacCollum thinks that it is incongruous to suppose that at some time this fibrous tissue will disappear and allow the testicle "to drop like a plummet" into the scrotum. In our series 5 patients with undescended testes who had been treated with antuitrin-S (total 3,000 units in each except 1 case that received 6,000 units), submitted to operation three to six months later. The same degree of fibrous adhesions and mechanical arrest seemed to be present in these as in cases which had not been treated by gonadotropic substance prior to operation. The mechanical obstruction to spontaneous or induced testicular descent as revealed by operation seems adequate explanation of failure of hormonal therapy.

One wonders if many of the successful results with endocrines reported in the literature were not obtained in cases of physiologic ectopy and not true undescended testes. By physiologic ectopy is meant the condition in which one finds a normally descended testis with a very active cremaster which pulls the gonad into a high scrotal, inguinal, or even abdominal position. This condition, also called ectopy en retour, has been little appreciated by most investigators. The factor at fault in this anomaly is the hyperactive cremaster (physiologic), while that in the case of the true undescended testis is the failure of complete descent (anatomic). Some instances of spontaneous descent of incompletely descended testes are undoubtedly cases of physiologic ectopy. It may be that anterior pituitary-like substance is valuable in the treatment of physiologic ectopy, but it should be remembered that such cases often descend spontaneously. It is not to be inferred that the writer believes that all of the reported cases of retained testes that have descended after a course of hormonal therapy are cases of physiologic ectopy. However, because of the results obtained with this therapy at this clinic, and because of the existence of mechanical causes for testicular arrest in most of the operated cases, it is believed that endocrine imbalance *alone* does not fully explain the cause or give a rational basis for treatment in *all* cases of true testicular maldescent.

There can be no doubt that in some cases of cryptorchidism gonadotropic hormones will cause descent of the testis into the scrotum; in others endocrine therapy is of no value and only surgery will remedy the aberrant position of the gonad. In a third group testicular descent or size may be enhanced by the pre- or postoperative use of glandular substances. Just what percentages of undescended testes fall in the above classifications are unknown. However, a method that gives the patient any chance of avoiding a surgical operation certainly merits trial; hence, the use of hormonal therapy, at least a preliminary form of treatment, seems indicated.

A SUGGESTED PLAN OF TREATMENT FOR THE UNDESCENDED TESTIS

It is known from the experiments of Moore and Wangenstein that the testis must be in the scrotum before spermatogenesis occurs or de-

generative changes will set in. Puberty in the male lies between the ages of 13 and 15 years, without regard to race, climate, or individual differences (Spangaro), the extremes being 9 years (Seammon) and 18 years (Crampton). Therefore, treatment of the congenitally retained gland may be deferred until the patient is 9 to 11 years old. If surgery is contemplated, there is no objection to operating upon a patient with uncomplicated retained testis at any earlier age, but it is unnecessary. The presence of a large associated hernia may necessitate earlier surgical intervention. The presence of an undescended testis precludes the use of a truss and the injection of sclerosing solution in the treatment of inguinal hernia. It is our practice at the University of Minnesota Hospitals to suggest first a trial of anterior pituitary-like substance in all uncomplicated cases of undescended testes before surgical procedures. Possibly the determination of gonadotropic hormone in the urine before treatment (Hess and others) will aid in the selection of these patients. It would be of practical value to know before treatment if there existed mechanical causes for the testicular maldescent, but unfortunately no way to determine this is known to date. There are various methods of administering hormonal therapy. While the available gonadotropic substances are well standardized, the dosages and interval of injection prescribed by various authors are rather empirical. At this clinic, the methods of treatment outlined above are still followed, except that greater dosages are given in some instances, as well as subsequent courses of injections, at two- to three-month intervals, if the patient is under 9 years of age. We have had no experience with extremely high dosages of gonadotropic hormones in the treatment of cryptorchids at this clinic as the cost is prohibitive. If, after six months of observation, no results have been observed with hormonal therapy, surgical treatment of the undescended testis is advised if the patient is 9 years or older.

SUMMARY

Treatment of the retained gonad may be deferred until the patient is 9 to 11 years old. With the hope that the case may be a favorable one, a course of treatment with pituitary-like substance may be tried first in cryptorchids before surgical procedures. Reports in the literature of cryptorchids treated by gonadotropic hormones reveal that in as high as 70 per cent of the cases there is descent of the testis into the scrotum. This form of therapy has been less efficacious in the cases treated to date at this clinic, degrees of descent being obtained in only 16 per cent of the cases so treated. No untoward effects resulting from hormonal therapy have been observed.

For reasons mentioned elsewhere, it is believed that endocrine imbalance *alone* does not fully explain the cause or give a rational basis for treatment in *all* cases of true testicular maldescent. However,

MacCollum thinks that it is incongruous to suppose that at some time this fibrous tissue will disappear and allow the testicle "to drop like a plummet" into the scrotum. In our series 5 patients with undescended testes who had been treated with antuitrin-S (total 3,000 units in each except 1 case that received 6,000 units), submitted to operation three to six months later. The same degree of fibrous adhesions and mechanical arrest seemed to be present in these as in cases which had not been treated by gonadotropic substance prior to operation. The mechanical obstruction to spontaneous or induced testicular descent as revealed by operation seems adequate explanation of failure of hormonal therapy.

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gonadotropic substance should be given at least a preliminary trial in the treatment of undescended testis, and, if no results are obtained, an orchiopexy should be performed.

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PRIMARY RETROPERITONEAL TUMORS

REPORT OF THREE CASES AND ONE HUNDRED SEVEN CASES FROM THE LITERATURE

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(From the Gynecological Service of the Mount Sinai Hospital and private practice)

THE present report is based upon two cases of primary solid retroperitoneal tumors and one retroperitoneal cyst unconnected in origin with any of the abdominal viscera. For reasons which will appear obvious, these three patients were subjected to different methods of treatment—the one to radiotherapy, the other two to operation.

Primary retroperitoneal tumors are not of frequent occurrence. They present unusual difficulties in diagnosis, operative intervention, and prognosis; in prognosis, because even the nonmalignant types are prone to recur, especially lipomas.

In previous communications I have described a neurogenic retroperitoneal growth (Schwannoma²⁷), as well as three tumor masses encountered retroperitoneally in the pelvis, which presented diagnostic problems.²⁸ The present discussion is limited to primary growths not arising from abdominal organs (liver, pancreas, adrenals, intestines, genital or urinary organs). Likewise, because the diagnostic problems and operative techniques are different, mesenteric and omental growths, although extraperitoneal, are not included. The few neoplasms described as specifically arising from residual urogenital embryonic rests also are not considered (Hansmann and Budd³⁶).

CASE REPORTS

CASE 1.—Gynecological Service, The Mount Sinai Hospital, A. M., female, aged 3½ years. The child had complained of fatigue and loss of weight for the last six months (loss of twenty-eight pounds in six months). Acute symptoms four weeks in duration. A slender child in the last degrees of emaciation; weight, forty pounds. In marked contrast to the state of nutrition was a greatly distended abdomen. Almost the entire abdomen was occupied by a firm yet apparently fluctuating mass arising from the left flank. Tympany was limited to a narrow zone along the right flank and epigastrium (Fig. 1). Rectal examination showed the Douglas free although pressed upon by the mass. A small uterus could be felt. X-rays of the chest were negative. Gastrointestinal x-ray showed the stomach compressed upward, the transverse and descending colon displaced to the right and backward. The abdomen showed a large homogeneous shadow (Fig. 2). The circumference of the abdomen at the umbilicus was 69 cm. The superficial abdominal veins were greatly distended.

The condition was considered inoperable, but exploration was decided upon. Operation, Nov. 21, 1929. Upon opening the abdomen, I found a large semifluctuant

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mass of the size shown in the diagram (Fig. 1) which I diagnosed as teratoma. The mass covered the entire posterior surface of the abdomen and had bulged into the mesentery of the small intestine as well as that of the mesosigmoid and descending colon, separating the leaves of the mesenteries and advancing to within 1 cm. of such portion of the small intestine as could be visualized. The intestine appeared secondarily adherent to the mass. The surface of the tumor beneath the posterior abdominal peritoneum was extremely friable and vascular. It burst during the examination, profuse hemorrhage ensuing. Several areas were taken for biopsy purposes. A Mikulicz drain was inserted, the end of which was drawn through the abdominal incision which was sutured except for passage for the drain.

The child recovered from this intervention, and, in order to give it the only possible chance, at first a radium pack was applied, Dec. 5, 1929, 10,000 mg. hours,

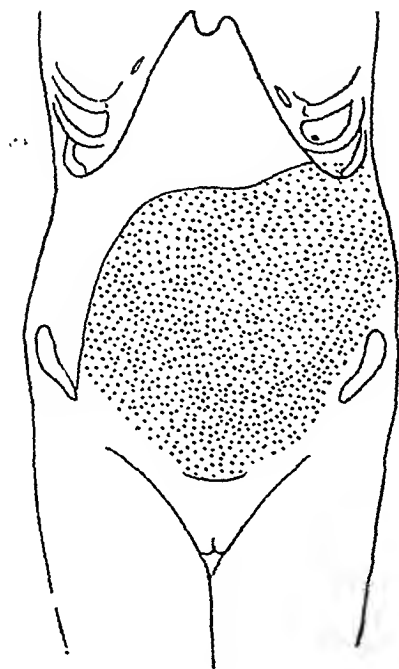


Fig. 1.—Case 1. Schematic outline of extent of tumor.

over fields of 6 by 8 cm., at a distance of 6 cm., with a filter of 0.1 mm. of platinum and 1 mm. of lead. Between Dec. 13, 1929, and Dec. 18, 1929, five high voltage x-ray exposures were given through the right and left gluteal regions (100 per cent). The child showed distinct improvement, the abdominal distention and mass subsiding. Between Feb. 8, 1930, and March 13, 1930, six treatments of high voltage x-ray were given through the anterior pelvis, right and left gluteal regions, totaling 66 per cent erythema dose. The improvement continued and therefore from May 27, 1930, to June 7, 1930, four more x-ray treatments were given, 60 per cent erythema dose, through the anterior abdomen, and 40 per cent through the right and left gluteal regions. The amount of x-ray given according to the old type of measurement amounted to 200 per cent to the right and left gluteal regions and 135 per cent to the anterior pelvis.

Within a year the child appeared perfectly well. Her abdominal and rectal examinations were normal and throughout the intervening

time she has not only continued to be in perfect health, but has shown normal growth and development. Now at the age of 17 years, eight and one-half years since the exploration, A. M. is a normal, healthy, well-built young woman. She has menstruated four times, September, 1936, May, August, and October, 1937. The genital organs are normal and



Fig. 2.—Case 1. X-ray of abdomen after barium meal. Stomach and small intestine crowded upward; transverse and descending colon pushed to right.

do not appear to have been permanently involuted by the large doses of radium and X-ray given.

The specimen consists of a myxomatous connective tissue which shows in places conspicuous capillary formations. In places there are smooth muscle bundles within the myxomatous tissue. Other areas consist of a very cellular fibroblastic tissue, the fibroblasts having a large pale

time she has not only continued to be in perfect health, but has shown normal growth and development. Now at the age of 17 years, eight and one-half years since the exploration, A. M. is a normal, healthy, well-built young woman. She has menstruated four times, September, 1936, May, August, and October, 1937. The genital organs are normal and



Fig. 2.—Case 1. X-ray of abdomen after barium meal. Stomach and small intestine crowded upward; transverse and descending colon pushed to right.

do not appear to have been permanently involuted by the large dose of radium and X-ray given.

The specimen consists of a myxomatous connective tissue which shows in places conspicuous capillary formations. In places there are small muscle bundles within the myxomatous tissue. Other areas consist of a very cellular fibroblastic tissue, the fibroblasts having a large



Fig. 5.—Case 2. First stage in development of tumor. Appendix removed; tumor freed from between leaves of mesosigmoid.

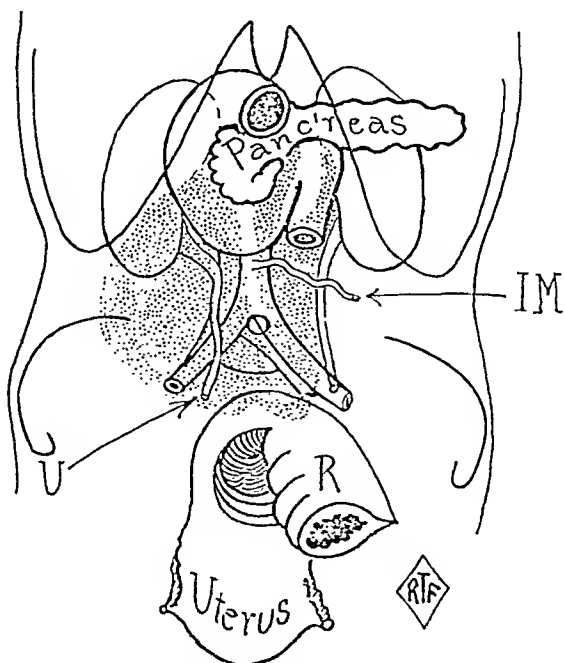


Fig. 6.—Case 2. Schema of retroperitoneal area, showing extent of growth.

umbilicus on the right side, lower on the left. Both flanks percussed dull. There was no fluid wave. The inguinal glands were normal. There was a small lipoma in the right buttock.

Pelvic examination: the uterus could not be differentiated from the mass which on the left reached down into the pelvis. The diagnosis was that of ovarian or uterine neoplasm, not malignant as Douglas' cul-de-sac appeared uninvolved.

Operation, Nov. 20, 1936, private pavilion, the Mount Sinai Hospital. A left paramedian suprapubic incision was made. An apparently cystic mass presented. Spread upon its anterior surface was a long horizontally pointing vermiform ap-

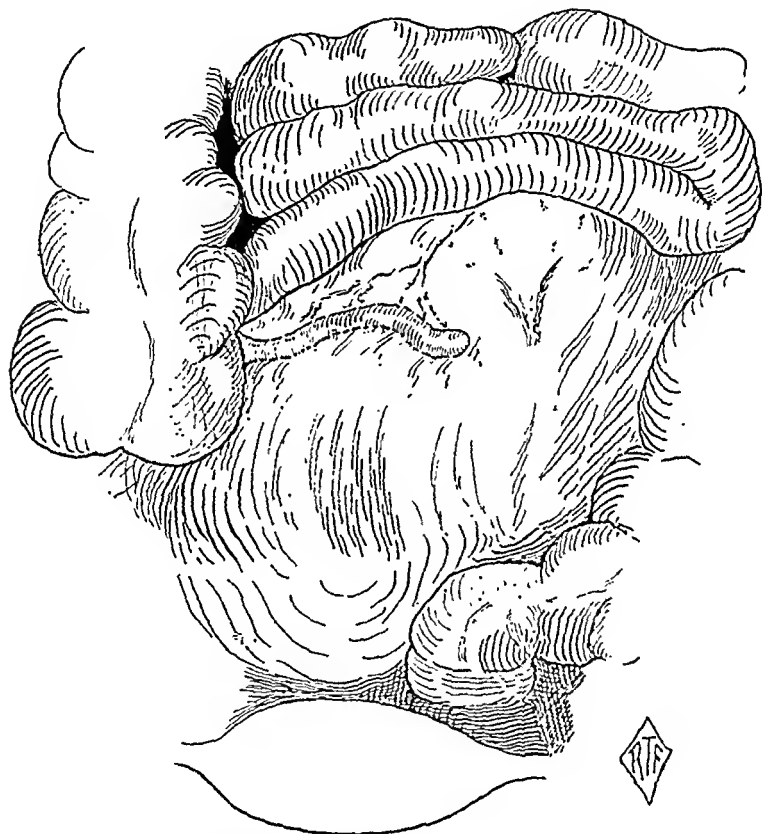


Fig. 4.—Case 2. Conditions on opening abdomen. Horizontal appendix; leaves of mesenterium and mesentery of small intestine separated by the growth; lower ileum fixed horizontally; mesosigmoid invaded.

pendix, its mesenterium separated and spread on the surface of the tumor. The tumor likewise had separated the mesentery of the terminal ileum, rising upward behind the cecum and ascending colon. (Fig. 4.)

The appendix was first freed by incising its mesenterium above and below, and then removed. The posterior peritoneal incision was extended vertically downward from the point at which the tip of the appendix had lain. At this stage both ovaries and tubes were found normal, the uterus enlarged by small fibroids to the size of a seven weeks' pregnancy. The posterior peritoneal incision could not be extended upward because the fixed, transversely running ileum was encountered.

The factors used were kv. 200; filter 1 mm. copper 1 mm. aluminum; F.S.D. 50 cm.; size of fields, 15 by 20 cm.

Four fields were used: right and left lower quadrants and right and left buttocks. The right and left lumbar regions were also treated. Left lower quadrant received, 1,224 r. units*; right lower quadrant, 918 r. units; left buttock, 969 r. units; right buttock, 1,020 r. units; left lumbar, 1,020 r. units; and right lumbar, 2,100 r. units.

The patient has been followed and has completely recovered, with a gain of ten pounds. She still wears an elastic stocking for the chronic but subsiding edema of the left leg. She occasionally receives progynon dihydroestradiol tablets to control the flushes following x-ray steriliza-

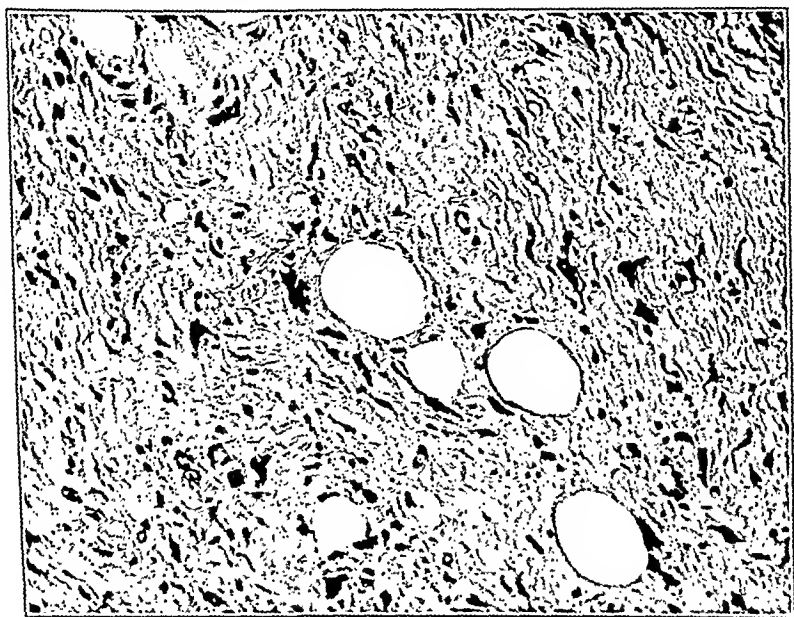


Fig. 8.—Case 2. Photomicrograph. Myxofibrosarcoma.

tion. Abdominal examination is normal. Pelvic examination shows a small uterus, the fibroids having receded; normal Douglas and adnexae.

The pathologic report from Dr. Paul Klemperer, pathologist to the Mount Sinai Hospital, in abstract is as follows: The specimen consists of two large masses, one 25 by 12 by 5 cm., the other 15 by 14 by 9 cm. with a small pedunculated mass 5 by 4 cm. (Fig. 7). The weight was 4 pounds. The tumor was soft, almost fluctuant, and encapsulated. The cut surface was homogenous, pale brown to pink, and gelatinous.

Microscopic examination shows the tumor to be a fibrolipomyxosarcoma. The fat plays a very small part in the entire mass of the tumor, being largely microscopic. (Fig. 8.)

*r. units measured in air.

(Figs. 4 and 5.) The lower pole of the growth was slowly developed, first from between the layers of the sigmoid mesocolon, then from behind the readily mobilized cecum, always keeping the intestine in view, profiting by dissectable layers. The growth was gradually pulled downward, vessels ligated as encountered, until its upper limit on the right side was finally reached (Fig. 6). The lower 10 cm. of the right ureter were embedded in a gutter of the tumor opening toward the right. The ureter was preserved. The upper limits of this portion of the growth covered the lower pole of the right kidney and ran behind the transverse portion of the duodenum. By now inserting the hand intraperitoneally above the obstructing transverse terminal iliac loop, it was discovered that another portion of the growth extended upward behind the stomach toward the diaphragm. This lobe of the tumor was developed by the same method and through the same posterior peritoneal opening. Great caution in following cleavage planes and visualization of anatomic landmarks was observed. The inferior mesenteric vessels lay between the right and left tumor masses, the left portion of which had likewise separated the layers of the

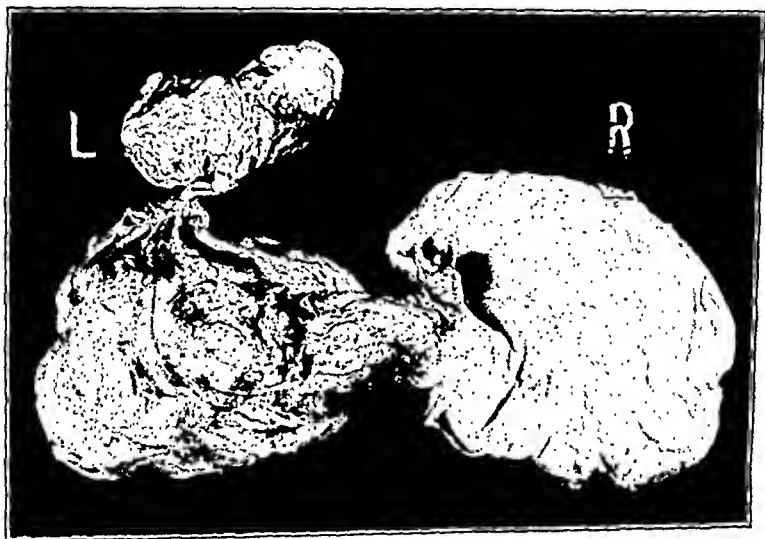


Fig. 7.—Case 2. Specimen. Two large flat masses joined by an isthmus situated over the division of the aorta. Smaller pedunculated growth near tail of pancreas and left crus of diaphragm. Weight, 4 pounds.

transverse mesocolon. A small outgrowth (Fig. 7) was removed in continuity with the left lobe and was situated on the left crus of the diaphragm.

The resulting huge retroperitoneal cavity (Fig. 6) was now carefully explored both by touch and as much as possible by vision. Small portions of the growth which had remained adherent to the transverse part of the duodenum were removed by the scalpel. The retroperitoneal cavity showed the lower pole of the right kidney, the right ureter throughout its length until it entered the pelvic cavity, the right psoas muscle, the vena cava, aorta, extraperitoneal portion of the duodenum as well as the tail of the pancreas. The inferior mesenteric vessels were completely isolated for several inches. The cavity appeared dry and therefore the posterior peritoneum was closed without drainage.

The patient made an uneventful and almost afebrile recovery until the tenth day when a phlebitis of the left leg developed. From January to March, 1937, Dr. William Harris gave the patient x-ray treatments to the pelvis and lumbar gutters. The dosage was as follows:

It follows that the majority are mesodermal in character. Of the 107 cases from the literature, only the 20 neuromas and 10 teratomas may be considered of ectodermal derivation (28 per cent).

Site.—The tumors, *sensu strictu*, present behind the posterior layer of the peritoneum. During their development, they may raise any of the abdominal viscera away from the posterior abdominal wall and secondarily may extend into the mesentery of the large and small intestine as well as downward, over, or alongside the promontory of the sacrum, into the pelvic connective tissues and sigmoid mesocolon. They have grown into the inguinal canal (Lundblad⁶⁵), Case 3, into the labium and buttock (Gough³³), and through the sacrosciatic foramen (Lundblad, Case 16).

When these neoplasms attain large size, their point of origin no longer may be determinable, as they encroach upon and adhere to any of the intra-abdominal organs—kidney, adrenal, duodenum, small intestine, colon, stomach, liver, and even gall bladder (Gehring, *see* Jackson⁴³).

Size.—Tumors of the size of a fist (König⁵⁰) up to gigantic growths weighing 63 German pounds (Waldeyer⁹⁸) and 69 avoirdupois pounds (Hirsch and Wells³⁹) are reported. In more recent times, such enormous proportions are less commonly observed although Gordon³² in 1925 successfully removed a teratoma weighing 26 pounds; Harrington³⁷ in 1934 removed a fibromyxolipoma of 47 pounds and Williams¹⁰³ in 1935, a lipomyxosarcoma of 51 pounds.

Gross Characters.—The growths may be solid, cystic, or a combination of both, as the polycystic teratomas. Solid tumors, usually coarsely lobulated, are pseudofluctuant if lipomas, or myxosarcomas, firmer if fibrous tissues predominate; in a few instances, bony (Davidović¹⁹) or calcareous tissues (Harrington³⁷) or both (Bode¹⁰) have been encountered. Even the malignant types, with the possible exception of round cell and fibrosarcomas, rarely show a markedly invasive tendency. The majority remain encapsulated. Small outgrowths, however, either connected by slender pedicles or entirely detached, are of frequent occurrence. These small growths are readily overlooked and may account for recurrence after apparently complete operative removal. This applies particularly to lipomas. Liebermann v. Wahlendorf,⁶² after removing a lipoma weighing 7,000 gm., during the final revision of the wound bed, discovered and removed fifteen additional small growths.

The color of these growths varies between yellow (lipoma), grayish (myxosarcoma), white (fibroma), pinkish to red (sarcoma), variegated (teratoma), depending upon the predominant tissues.

The cystic tumors are thin walled and, according to the classification of Moynihan,⁵⁵ consist of serous, chylous, hydatid, sanguineous, dermoid, and cystic sarcomas. The classification given by Cornioley¹⁵ is almost identical. Lahey and Eckerson⁵² add to these Wolffian (urogenital rests), mesocolic (residual peritoneal pockets), and traumatic or

CASE 3.—There is a third case which I operated upon sometime between 1907 and 1912, the full details of which cannot be found. The patient was a young woman in her twenties, who complained of marked loss of weight and slow increase in size of the abdomen. The preoperative diagnosis was that of an unusually large ovarian cyst. Upon opening the abdomen, the entire abdominal contents appeared to be lying upon a water bed several inches in thickness, with prominence of the widely separated leaves of the mesentery of the small intestine. The hand, when introduced up to the diaphragm, noted continuation of the fluctuant mass to behind the liver. An avascular portion of the lower leaf of the separated mesentery was incised, a cleavage plane readily encountered. The cyst did not extend downward beyond the promontory and was entirely separate from the normal female genitals. A trocar was introduced into the cyst cavity and several gallons of a light brown fluid drained off. The cyst was then mobilized, purely by sense of touch. Very few vessels were encountered requiring ligation. After several feet of cyst wall had been drawn out through the abdominal wound, the lowermost posterior portion was found firmly adherent to the plainly visualized mesenteric vessels and could not be separated from their trunk. Therefore the redundant portions of the cyst were resected, the cyst edge sutured to the skin edge, and the residual cavity packed with a Mikulicz drain. The sinus closed in the course of some weeks.

This patient was followed for more than six years and remained in perfect health. She was then lost sight of. The cyst wall consisted of a fibrous layer lined with a single layer of low endothelium.

DISCUSSION

The literature of retroperitoneal growths not arising from any of the abdominal viscera has been collected by Steele, 1900,⁹⁰ Liebermann v. Wahlendorf, 1921,⁶² Andrews, 1923,³ Schmid, 1923,⁸⁷ as well as in several abstract reports from the Mayo Clinic, 1924-1932. (These, however, consist mainly of mesenteric tumors.) Judd and Larson¹⁵ include tumors of the renal capsule, undescended testis, pancreas, and kidney (13 of 46 cases).

The repetitions and overlapping of these various articles are so confusing as to nullify any attempt at complete statistical presentation. A search of the literature between 1925 and 1936 shows 107 additional cases, excluding purely mesenteric and omental growths, as well as those specifically mentioned as arising from residual urogenital embryonic rests (Hansmann and Budd³⁶).

The older literature appears to begin with Lobstein,⁶⁴ who in 1829 gave an accurate description of retroperitoneal growths including their gross characters and location. Virchow⁹⁷ in his *Geschwülste*, 1856, likewise mentions these growths. Gurlt³⁵ among 894 sarcomas (total cases, 16,637) found only 1 retroperitoneal growth, while Judd¹⁵ in his recent statistics from the Mayo Clinic, found 25 mesenteric tumors in among 820,000 cases. Rasmussen³² noted 9 retroperitoneal tumors in 42,000 patients. The older literature is referred to in detail by Steele.⁹¹

Origin.—The tumors in question have in common their derivation from retroperitoneal tissues, including fat, areolar connective tissue, fasciae, lymph glands, lymphatics, and sympathetic nervous structures.

43 per cent showed metastases. Andrews³ reports metastases in 33 per cent in the cases reported to 1923, occurring in liver, lungs, lymph glands, etc. Nikolski⁷² (as noted in abstract) in 115 cases likewise noticed 33 per cent metastases. This is in marked contrast to the 107 cases which I report in which metastases were noted in only 4, 3.7 per cent, and of sarcomas, at the most, in 13.2 per cent.

Clinical Symptoms.—Small growths usually are discovered by accident either by the patient or by the examining physician. More usually, a slow, progressive enlargement of the abdomen is noted by the patient who eventually seeks medical advice. Vague digestive disturbances, such as anorexia, eructations, heartburn, colicky pains, and constipation, are complained of. Steele⁹⁰ found edema, especially of the lower extremities, neuralgic pains, and, in one case, femoral phlebitis. A progressive loss of weight and strength appears the universal rule. In rare instances acute abdominal symptoms have developed due to intraperitoneal rupture, peritonitis, or hemorrhage.

Hesse^{33a} has described a difference in surface temperature of the two lower extremities as a sign of retroperitoneal growths due to pressure on the abdominal sympathetic nerves. At first the surfaces' temperature of the limb on the side of the lesion is diminished (stimulation of lumbar sympathetic). Later the temperature is increased as the pressure on the nerves decreases their conductivity. During the stage of decreased temperature, the pilomotor and sweat reflexes are increased (Zaiceva,¹⁰⁵ Vinogradov⁹⁵).

Ileus (Burger and Osborne¹²), pyonephrosis due to pressure on the ureter, intraperitoneal hemorrhage (Dinet²¹), and rupture into the stomach (autopsy finding, Dahl¹⁷) are on record.

Termination.—If unoperated, and this is best noted in the older literature, a slowly progressive enlargement of the abdomen eventually leads to death from compression of the lungs by the elevation of the diaphragm, compressions of the intestine, kidneys, and ureters (case of Jackson,⁴³ 1889). Steele⁹⁰ reports two sarcomas of which one had perforated into the peritoneal cavity, one into the stomach. Dahl¹⁷ likewise reports a case of gastric invasion.

Diagnosis.—Diagnosis will always prove difficult. Small growths are regularly considered of ovarian, uterine, hepatic, intestinal, or renal origin, depending upon their location, mobility, and the sex of the patient. Today, with the aid of gastrointestinal x-ray and pyelography, renal and intestinal growths may in the majority of instances be ruled out preoperatively. However, many of these growths, as can be seen from the summary of case reports, are perirenal in location and may be secondarily adherent to the kidney capsule or even parenchyma so that even these diagnostic aids may prove misleading.

blood cysts. The cysts consist of a fibrous wall with flat endothelial lining or devoid of a lining endothelium. The fluid content may be clear, sanguineous or fatty (dermoid).

Combination of solid and cystic portions result either from fluidification of parts of solid tumors such as lipomas, myxomas or sarcomas or are found in true embryomas which contain solid tissue, honeycombed by cysts.

Microscopic characteristics require no detailed description. The following summary of findings in cases submitted to microscopic investigation is taken from Liebermann v. Wahlendorf,⁶² in 153 cases in which microscopic examination had been performed:

| | | |
|------------------|----|----------------|
| Pure lipoma | | 70 cases 45.7% |
| Mixed tumor | | 83 cases 54.0% |
| Fibrolipoma | 31 | 62 cases 40.5% |
| Myxoma | 16 | |
| Fibromyxolipoma | 15 | |
| Sarcoma | | 21 cases 13.8% |
| Myxosarcoma | 13 | |
| Fibroliposarcoma | 5 | |
| Liposarcoma | 3 | |

SUMMARY OF CASE REPORTS IN TABLE I

Of the 107 cases which I have collected from the literature between 1925 and 1936, there were:

| | | | |
|---------|----|------------|----|
| Fibroma | 8 | Sarcoma | 38 |
| Lipoma | 12 | Neurogenic | 20 |
| Myxoma | 11 | Teratoma | 10 |
| | | Cysts | 8 |

| | |
|----------------------------|---|
| 107 cases collected | |
| 8 autopsy reports | |
| 98 operated | |
| 1 not operated | |
| 18 postoperative deaths | |
| 18.4% mortality: | |
| 29 cases were followed up: | |
| Well 2½ mo. | 1 |
| Well 6 mo. | 1 |
| Well 1 yr. | 4 |
| Well 1¼ to 2 yr. | 6 |
| Well 2 to 3 yr. | 6 |
| Well 3 to 5 yr. | 4 |
| Well 5 to 10 yr. | 2 |
| Well 10 to 15 yr. | 3 |
| Well 15 to 16 yr. | 2 |

Metastases are less common than local recurrences. In the older literature Wakley²⁸ described a lipomyxoma with small sarcomatous nodules in the liver and lungs. Of the 44 sarcomas collected by Steele,²⁹

| | RESULT | WEIGHT | |
|---------|------------------------------|--------------------|---|
| | Recovered | 4,750 gm. | Bladder twice injured; no follow-up |
| | Recovered | 10 by 16 by 12 cm. | In 3 divisions |
| | - | - | |
| | Recovered | 11 by 8 by 7 cm. | Intestinal resection |
| | Recovered | 4.2 kg. | Resected tranverse colon; well 2 yr. postoperatively |
| | Recovered | 16½ lb. | Later pleuroabdominal fistula; 2 mon. convalescence |
| | Recovered | - | Well 14 yr. postoperatively |
| | Recovered | - | Well 15 yr. postoperatively |
| | Recovered | Large | Nephrectomy |
| | Recovered | - | Died 7 yr. after second operation from recurrence |
| | Recovered | 635 gm. | |
| | Recovered | 8 by 5 by 5½ cm. | Extension into femoral canal |
| | Recovered | - | Extension into inguinal canal |
| | Recovered | 3½ kg. | Well 3 yr. postoperatively |
| | Recovered | 22½ lb. | Ureter in tumor; nephrectomy |
| | Recovered | 850 gm. | Adherent to lower pole right kidney |
| | Recovered | 250 gm. | Like actively proliferative bone marrow |
| | Recovered | - | Operations for 2 recurrences in 5 yr. |
| | Recovered | - | Given x-ray; died |
| and | Recovered | 6,150 gm. | Previous exploratory lap. 2 yr. ante |
| s | Recovered | 10 lb. | Intra-abdominal untouched; excised labial and buttock |
| | Recovered | 2,900 gm. | |
| | Recovered | 25 lb. | |
| atory | Died 6 wk. | 25 lb. | Adherent stomach, colon, tumor ruptured (aspiration!) |
| | Recovered | 9 kg.; 7½ kg. | Alive 6 yr. after last operation |
| r | Recovered | 16 by 8 cm. | Well 2¼ yr. postoperatively |
| | - | 1640 gm. | 3 operations; infiltrating muscle at last operation |
| | | 1,300 gm. | |
| | Recovered | 47 lb. | With calcification and necrosis |
| | Died 1 day postoperatively | 4,196 gm. | Adherent to postgastric wall |
| | Recovered | 10 kg. | |
| | Recovered | - | Died 3¼ yr. postoperatively |
| | Recovered | Child's head | Well 7½ yr. postoperatively |
| oratory | Recovered | - | Ra. needles, well 1 yr. later |
| psy | - | - | From retroduodenal nodes |
| | Recovered | - | Deep x-ray postoperatively; well 1 yr. later |
| | Recovered | - | Sigmoid injured, "Vorlagerung" |
| | Recovered | - | |
| | Recovered | Large | Died 9 mo. postoperatively with metastasis |
| | Recovered | - | Alive 11 yr. postoperatively |
| | Recovered | - | 1 lit. bl. in abd., duod. inj. died 6 mo. postoperatively |
| | Died 10 days postoperatively | - | - |
| p. | Recovered | - | Died 2 yr. postoperatively |

TABLE

| YEAR | TYPE | AUTHOR* | AGE | SEX | DURATION | SITE |
|------|----------------------|-------------------------------|-----|-----|----------|--|
| 1926 | Fibroma | Dannheisser | 37 | M | - | Abd. retroperitoneal |
| 1928 | Fibromyoma | Kreiner | 24 | F | - | Abd. retroperitoneal |
| 1929 | Fibroma | Kanjan and Krivo- borskaja | - | - | - | Abd. retroperitoneal and trans. meso. |
| 1932 | Fibroma | XIII Rankin and Major | 25 | F | 1½ yr. | Retroperitoneal mesenteric |
| 1933 | Fibroma | Bader | 40 | F | Months | Retroperitoneal mesocolon |
| 1934 | Fibroma | Wolfer | 31 | M | 5 yr. | Retroperitoneal |
| 1935 | Fibroma | V Rasmussen | 45 | F | - | Retroperitoneal |
| | Fibroma | VI Rasmussen | 20 | F | - | Retroperitoneal |
| 1926 | Lipoma | I Pritzi | 62 | F | 5 mo. | Retrocolic left renal |
| 1929 | Lipoma | Hosemann | 51 | M | - | Retrocolic |
| 1931 | Lipoma | French | 6 | F | - | Perirenal |
| 1931 | Lipoma | II Burger and Osborne | 61 | M | - | Right iliac femoral |
| 1932 | Lipoma | III Lundblad | 52 | M | 3 yr. | Iliac inguinal |
| | Lipofibroma | II Lundblad | 63 | F | - | - |
| 1932 | Lipoma | Bettman and Serby | 40 | M | 7 mo. | Right retrocolic |
| 1933 | Lipoma | Pemberton and McCaughan | 36 | F | 12 yr. | Perirenal |
| 1933 | Lipoma | Blaisdell | 64 | F | - | Retroperitoneal |
| 1932 | Lipofibroma | Quenu | 42 | F | - | Perirenal |
| 1934 | Lipofibroma | De Renzi | 51 | F | - | Subhepatic |
| 1926 | Lipomyxoma | Krogus | 51 | F | 2 yr. + | Perirenal |
| 1927 | Myxoma | Gough | 35 | F | 12 yr. | Abd. vulvar, gluteal |
| 1930 | Fibromyxoma | Lind | 39 | F | 3 mo. | Retroperitoneal + pelvic |
| 1932 | Fibromyxoma | XIV Rankin and Major | 50 | M | 10 yr. | Mesentery |
| 1932 | Lipomyxoma | Wechsler | 65 | M | 3½ yr. | Retroperitoneal |
| 1932 | Lipofibromyxoma | I. Lundblad | 46 | F | ? | Retroperitoneal |
| 1932 | Myxoleiomyoma | Nordland | 26 | M | - | Upper left retro- peritoneal |
| 1933 | Fibromyxolipoma | Riche et al. | 51 | M | 7 yr. | Left flank |
| 1934 | Fibromyxolipoma | Harrington | 28 | M | 17 yr. | Retroperitoneal |
| 1934 | Fibromyxoma | I Phillips | 63 | F | 4 yr. | Gastrohepatic |
| 1934 | Fibromyxolipoma | Pemberton and Whit- lock | 47 | F | 1 yr. | - |
| 1929 | Sarcoma | Gnleke | - | - | - | Retroperitoneal |
| 1932 | Sarcoma | Duroselle | 64 | F | - | Perirenal |
| 1932 | Sarcoma | Newton | 17 | F | Months | Retrocecal |
| 1932 | Sarcoma | Didicé | - | - | - | Retrocolic |
| 1934 | Sarcoma | Walters and Priestley | 43 | M | - | Mesosigmoid |
| 1926 | Fibrosarcoma | II Pritzi | 41 | F | 4 mo. | Retrocecal and sig- moid |
| 1934 | Spindle cell sarcoma | II Lepontre | 64 | F | - | Perirenal |
| 1932 | Spindle cell | VI Lundblad | 48 | F | 1 yr. | Presacral |
| | Telangiectatic | IV Lundblad | 55 | F | - | Retrocecal and per- renal |
| | sarcoma | V Lundblad | 30 | M | 4 mo. | Retrocolic |
| | Telangiectatic | | | | | |
| | sarcoma | | | | | |
| | Lymphosarcoma | VII Lundblad | 65 | F | Years | Retroperitoneal |

*Where more than one case was reported by the same author, the Roman numerals refer to the number of the case in the article quoted.
 flap., laparotomy; op., unclassified operation.

1

| OPER. | RESULT | WEIGHT | |
|--------------------|------------------------------|--------------------|---|
| Lap.† | Recovered | 4,750 gm. | Bladder twice injured; no follow-up |
| Lap. | Recovered | 10 by 16 by 12 cm. | In 3 divisions |
| Lap. | - | - | |
| Lap. | Recovered | 11 by 8 by 7 cm. | Intestinal resection |
| Lap. | Recovered | 4.2 kg. | Resected tranverse colon; well 2 yr. postoperatively |
| Lap. | Recovered | 16½ lb. | Later pleuroabdominal fistula; 2 mon. convalescence |
| Lap. | Recovered | - | Well 14 yr. postoperatively |
| Lap. | Recovered | - | Well 15 yr. postoperatively |
| Lap. | Recovered | Large | Nephrectomy |
| 2 op.† | Recovered | - | Died 7 yr. after second operation from recurrence |
| Op. | Recovered | 635 gm. | |
| Lap. | Recovered | 8 by 5 by 5½ cm. | Extension into femoral canal |
| Lap. | Recovered | - | Extension into inguinal canal |
| Op. | Recovered | 3½ kg. | Well 3 yr. postoperatively |
| Op. | Recovered | 22½ lb. | Ureter in tumor; nephrectomy |
| Lap. | Recovered | 850 gm. | Adherent to lower pole right kidney |
| Op. | Recovered | 250 gm. | Like actively proliferative bone marrow |
| 3 op. | Recovered | - | Operations for 2 recurrences in 5 yr. |
| Lap. | Recovered | - | Given x-ray; died |
| Lumbar | Recovered | 6,150 gm. | Previous exploratory lap. 2 yr. ante |
| Labial and buttock | Recovered | 10 lb. | Intra-abdominal untouched; excised labial and buttock |
| Lap. | Recovered | 2,900 gm. | |
| Lap. | Recovered | 25 lb. | |
| Exploratory | Died 6 wk. | 25 lb. | Adherent stomach, colon, tumor ruptured (aspiration!) |
| 5 op. | Recovered | 9 kg.; 7½ kg. | Alive 6 yr. after last operation |
| Lumbar | Recovered | 16 by 8 cm. | Well 2¼ yr. postoperatively |
| 3 op. | - | 1610 gm. | 3 operations; infiltrating muscle at last operation |
| | | 1,300 gm. | |
| Lap. | Recovered | 17 lb. | With calcification and necrosis |
| Lap. | Died 1 day postoperatively | 4,196 gm. | Adherent to postgastric wall |
| Op. | Recovered | 10 kg. | |
| Lap. | Recovered | - | Died ¾ yr. postoperatively |
| Op. | Recovered | Child's head | Well 7½ yr. postoperatively |
| Exploratory | Recovered | - | Ra. needles, well 1 yr. later |
| Autopsy | - | - | From retroduodenal nodes |
| Lap. | Recovered | - | Deep x-ray postoperatively; well 1 yr. later |
| Lap. | Recovered | - | Sigmoid injured, "Vorlagerung" |
| Op. | Recovered | - | Died 9 mo. postoperatively with metastasis |
| Lap. | Recovered | Large | Alive 11 yr. postoperatively |
| Lap. | Recovered | - | 1 lit. bl. in abd., duod. inj. died 6 mo. postoperatively |
| Lap. | Died 10 days postoperatively | - | - |
| Lap. | Recovered | - | Died 2 yr. postoperatively |

| YEAR | TYPE | AUTHOR* | AGE | SEX | DURATION | SITE |
|------|------------------------|--------------------------|-----|-----|----------|---------------------------------------|
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| 1934 | Fibroma | Wolfer | 31 | M | 5 yr. | Retroperitoneal |
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| | Fibroma | VI Rasmussen | 20 | F | - | Retroperitoneal |
| 1926 | Lipoma | I Pritzi | 62 | F | 5 mo. | Retrocolic left renal |
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| 1932 | Lipoma | III Lundblad | 52 | M | 3 yr. | Iliac inguinal |
| | Lipofibroma | II Lundblad | 63 | F | - | - |
| 1932 | Lipoma | Bettman and Serby | 40 | M | 7 mo. | Right retrocolic |
| 1933 | Lipoma | Pemberton and McCaughan | 36 | F | 12 yr. | Perirenal |
| 1933 | Lipoma | Blaisdell | 64 | F | - | Retroperitoneal |
| 1932 | Lipofibroma | Quenu | 42 | F | - | Perirenal |
| 1934 | Lipofibroma | De Renzi | 51 | F | - | Subhepatic |
| 1926 | Lipomyxoma | Krogus | 51 | F | 2 yr. + | Perirenal |
| 1927 | Myxoma | Gough | 35 | F | 12 yr. | Abd. vulvar, gluteal |
| 1930 | Fibromyxoma | Lind | 39 | F | 3 mo. | Retroperitoneal + pelvic |
| 1932 | Fibromyxoma | XIV Rankin and Major | 50 | M | 10 yr. | Mesentery |
| 1932 | Lipomyxoma | Wechsler | 65 | M | 3½ yr. | Retroperitoneal |
| 1932 | Lipofibromyxoma | I. Lundblad | 46 | F | ? | Retroperitoneal |
| 1932 | Myxoleiomyoma | Nordland | 26 | M | - | Upper left retroperitoneal |
| 1933 | Fibromyxolipoma | Riche et al. | 51 | M | 7 yr. | Left flank |
| 1934 | Fibromyxolipoma | Harrington | 28 | M | 17 yr. | Retroperitoneal |
| 1934 | Fibromyxoma | I Phillips | 63 | F | 4 yr. | Gastrohepatic |
| 1934 | Fibromyxolipoma | Pemberton and Whitlock | 47 | F | 1 yr. | - |
| 1929 | Sarcoma | Guleke | - | - | - | Retroperitoneal |
| 1932 | Sarcoma | Duroselle | 64 | F | - | Perirenal |
| 1932 | Sarcoma | Newton | 17 | F | Months | Retrocolic |
| 1932 | Sarcoma | Didie | - | - | - | Retrooduodenal |
| 1934 | Sarcoma | Walters and Priestley | 43 | M | - | Mesosigmoid |
| 1926 | Fibrosarcoma | II Pritzi | 11 | F | 4 mo. | Retrocolic and sigmoid |
| 1934 | Spindle cell sarcoma | II Lepoutre | 64 | F | - | Perirenal |
| 1932 | Spindle cell | VI Lundblad | 48 | F | 1 yr. | Presacral |
| | Telangiectatic sarcoma | IV Lundblad | 55 | F | - | Retrocolic and perirenal |
| | Telangiectatic sarcoma | V Lundblad | 30 | M | 1 mo. | Retrocolic |
| | Lymphosarcoma | VII Lundblad | 65 | F | Years | Retroperitoneal |

*Where more than one case was reported by the same author, the Roman numerals refer to the number of the case in the article quoted.

lap., Laparotomy; *op.*, undescribed operation.

—CONT'D

| OPER. | RESULT | WEIGHT | |
|-------------------|-----------------------------|-----------------|---|
| Lap. | Died 1 day postoperatively | Large | — |
| Lap. | Recovered | 8 cm. diameter | Well 4 yr. postoperatively |
| Op. | ? | 1 kg. | 1930, fibroma removed; nephrectomy |
| Lap. | Died 1 day postoperatively | — | Adherent to intestine |
| Op. | Recovered | Huge | Nephrectomy |
| Op. | Died | 930 gm. | No metastases |
| Autopsy | — | — | From retroperitoneal lymph glands |
| Autopsy | — | — | Had ulcerated into stomach |
| Autopsy | — | — | Advanced retroperitoneal sarcomas |
| Op. | Died | — | Died of shock |
| Exploratory | — | Size fist | Biopsy |
| Autopsy | — | — | Metastasis lungs and lymph nodes |
| Lap. | Recovered | — | Vena cava torn and sutured; in 6 months, metastasis |
| Lap. | — | — | Nephrectomy |
| Not op. | — | — | Inoperable |
| Exploratory | Died 3 wk. | 22 lb. | Obstruction 5 weeks postoperatively from retroperitoneal invagination and intussusception by recurrence |
| Lumbar second op. | Died 5 wk. postoperatively | — | Well 2½ mon. postoperatively |
| Lap. | Recovered | 3,300 gm. | |
| Lap. | Recovered | 15 cm. diameter | |
| Op. | Recovered | Size fist | Given x-ray; well 1½ yr. postoperatively |
| Lap. | Recovered | Man's head | Adherent to liver, cava, kidney vessels; well 1½ yr. later |
| Op. | Died weeks postoperatively | — | |
| Op. | Died | — | |
| Lumbar | Recovered | 4,300 gm. | Nephrectomy (pyonephrosis); no follow-up |
| Lumbar | Recovered | 345 gm. | First operation removed large and 4 small tumors |
| Second op. | Died 3 mo. | — | Second operation 9 mo. later with nephrectomy |
| lumbar 4 op. | 2nd p.o. Recovered | 51 lb. | One exploratory, biopsy, lipoma; 2.2 yr. later, 51 lb. with nephrectomy sarcoma; 3.5 yr. later, peritoneal infiltration; 4.3 yr. later, exploratory |
| Lap. | Died | — | Rectum torn, peritonitis |
| Lap. | — | — | Solid, only partial removal |
| Lap. | Recovered | 9 by 11 cm. | Right ureter anterior to mass |
| Lap. | Recovered | Man's head | Well 2½ yr. postoperatively |
| Autopsy | — | — | Contained also bone and cartilage |
| Op. | Died 3 days postoperatively | Large | — |
| Lumbar | Recovered | — | Well 1 yr. postoperatively |
| Exploratory | Recovered | — | Biopsy, deep x-ray; well 2½ yr. postoperatively |
| Lap. | Recovered | — | Well 2 yr. postoperatively |
| Lap. | Recovered | — | Well 1 yr. postoperatively |
| Lap. | Recovered | 20 cm. diameter | Injured urethra and prostate; well 4 yr. postoperatively |
| Lap. | Recovered | — | No follow-up |
| Lap. | Recovered | Cystic | Well 5 yr. postoperatively |

TABLE I

| YEAR | TYPE | AUTHOR* | AGE | SEX | DURATION | SITE |
|------|----------------------------------|---------------------------|-----|-------|----------|----------------------------------|
| | Polymorph. & lymph | VIII Lundblad | 34 | F | 1 mo. | Retrocolic |
| 1933 | Spindle cell sarcoma | Eliason and Ferguson | 38 | F | 8 mo. | Transverse mesocolic |
| 1933 | Fibrosarcoma | Judd and Larson | - | M | 2 yr. | Perirenal |
| 1933 | Fibrosarcoma | Arenas | 32 | F | 7 mo. | Perirenal |
| 1933 | Fibrosarcoma | MacLeod | 55 | M | 6 mo. | Perirenal |
| 1934 | Spindle cell | Suzuki | 12 | M | 6 mo. | Retroperitoneal |
| 1934 | Spindle cell | Craciun et al. | 55 | M | - | Retroperitoneal |
| 1934 | Fibrosarcoma | I Dahl | 74 | F | - | Retroperitoneal |
| 1934 | Lymphosarcoma | Irwin | 47 | F | 1 mo. ? | |
| | Round cell sarcoma | I Burger and Osborne | 49 | M | 2 mo. | Upper right retro- duodenal |
| 1932 | Lymphosarcoma | Castellano et al. | 39 | M | - | Retroduodenal |
| 1932 | Angiosarcoma | Beitzke | 38 | F | - | Retroperitoneal |
| 1929 | Polymorphous | Nikolski | 26 | F | 1 mo. | Retroperitoneal |
| | | Nikolski | 48 | F | 5 mo. | Retroperitoneal |
| | | Nikolski | 50 | F | 5 mo. | Retroperitoneal |
| | Leiomyosarcoma | IV Phillips | 42 | M | 1 yr. | Perirenal |
| 1931 | Myxosarcoma | III Burger and Osborne | 47 | F | 5 mo. | Retrocecal |
| 1925 | Fibromyxosarcoma | Tammanu | 60 | M | 5 yr. | Retroperitoneal |
| 1925 | Fibromyxosarcoma | Leichner | 48 | M | 1 mo. | Retroduodenal |
| 1928 | Fibromyxosarcoma | I Kreiner | 32 | F | 1 yr. | Retrocolic |
| | Fibromyxosarcoma | III Kreiner | 70 | F | - | Gastrocolic and retroduodenal |
| 1928 | Myochondro- osteofibrosarcoma | II Davidović | - | - | - | |
| | Fibromyosarcoma | I Davidović | - | - | - | |
| 1931 | Myxosarcoma | Kitamura | 69 | M | - | Retroperitoneal |
| 1931 | Fibromyosarcoma | Bange | 56 | M | 2 yr. | Perirenal |
| 1934 | Liposarcoma | I Lepoutre | 32 | F | - | Perirenal |
| 1935 | Lipomyxosarcoma | Williams | 65 | F | 4 yr. | Perirenal |
| 1925 | Neuroma | Krumbein | 49 | M | - | Perirectal |
| 1927 | Ganglion-neuro- fibroma | Neumann | 14 | F | - | Retroperitoneal pelvic |
| 1929 | Neurinoma | Köuig | 28 | M | - | Cava and sacroiliac joint |
| 1929 | Ganglion neuroma | Guleke | - | - | - | |
| 1931 | Gliosarcoma | Bode | 8 M | fetus | - | Retroperitoneal |
| 1931 | Ganglioneuroma | McFarland | 12 | F | - | Lap. |
| 1932 | Ganglioneuroma | Hortolomee et al. | 50 | F | - | Retrocolic |
| 1932 | Neurogenic sarcoma | Adair | 13 | M | - | Pelvic |
| 1932 | Fibroncurinoma | IX Lundblad | 41 | F | 1 yr. | Retroperitoneal |
| | Fibroncurinoma | X Lundblad | 52 | F | - | Retroperitoneal |
| | Neuroma gangliare | XI Lundblad | 29 | M | 7 mo. | Pelvic |
| 1933 | Sympathicoblastoma | Fels | 32 | F | - | |
| 1933 | Schwannoma | Frank | 30 | F | 7 yr. | Retroperineal |

—CONT'D

| OPER. | RESULT | WEIGHT | |
|-------------------|-----------------------------|-------------------------|---|
| Lap. | Died 1 day postoperatively | Large | — |
| Lap. Op. | Recovered ? | 8 cm. diameter 1 kg. | Well 4 yr. postoperatively 1930, fibroma removed; nephrectomy |
| Lap. | Died 1 day postoperatively | — | Adherent to intestine |
| Op. | Recovered | Huge | Nephrectomy |
| Op. | Died | 930 gm. | No metastases |
| Autopsy | — | — | From retroperitoneal lymph glands |
| Autopsy | — | — | Had ulcerated into stomach |
| Autopsy | — | — | Advanced retroperitoneal sarcomas |
| Op. | Died | — | Died of shock |
| Exploratory | — | Size fist | Biopsy |
| Autopsy | — | — | Metastasis lungs and lymph nodes |
| Lap. | Recovered | — | Vena cava torn and sutured; in 6 months, metastasis |
| Lap. | — | — | Nephrectomy |
| Not op. | — | — | Inoperable |
| Exploratory | Died 3 wk. | 22 lb. | Obstruction 5 weeks postoperatively from retroperitoneal invagination and intussusception by recurrence |
| Lumbar second op. | Died 5 wk. postoperatively | — | Well 2½ mon. postoperatively |
| Lap. | Recovered | 3,300 gm. | |
| Lap. | Recovered | 15 cm. diameter | |
| Op. | Recovered | Size fist | Given x-ray; well 1½ yr. postoperatively |
| Lap. | Recovered | Man's head | Adherent to liver, cava, kidney vessels; well 1½ yr. later |
| Op. | Died weeks postoperatively | — | |
| Op. | Died | — | |
| Lumbar | Recovered | 4,300 gm. | Nephrectomy (pyonephrosis); no follow-up |
| Lumbar | Recovered | 345 gm. | First operation removed large and 4 small tumors |
| Second op. lumbar | Died 3 mo. 2nd p.o. | — | Second operation 9 mo. later with nephrectomy |
| 4 op. | Recovered | 51 lb. | One exploratory, biopsy, lipoma; 2.2 yr. later, 51 lb. with nephrectomy sarcoma; 3.5 yr. later, peritoneal infiltration; 4.3 yr. later, exploratory |
| Lap. | Died | — | Rectum torn, peritonitis |
| Lap. | — | — | Solid, only partial removal |
| Lap. | Recovered | 9 by 11 cm. | Right ureter anterior to mass |
| Lap. | Recovered | Man's head | Well 2½ yr. postoperatively |
| Autopsy | — | — | Contained also bone and cartilage |
| Op. | Died 3 days postoperatively | Large | — |
| Lumbar | Recovered | — | Well 1 yr. postoperatively |
| Exploratory | Recovered | — | Biopsy, deep x-ray; well 2½ yr. postoperatively |
| Lap. | Recovered | — | Well 2 yr. postoperatively |
| Lap. | Recovered | — | Well 1 yr. postoperatively |
| Lap. | Recovered | 20 cm. diameter | Injured urethra and prostate; well 4 yr. postoperatively |
| Lap. | Recovered | — | No follow-up |
| Lap. | Recovered | Cystic | Well 5 yr. postoperatively |

TABLE I

| YEAR | TYPE | AUTHOR* | AGE | SEX | DURATION | SITE |
|------|-----------------------|---------------------------|-----|-----|----------|------------------|
| 1933 | Ganglioneuroma | Schleifstein | 18 | F | - | Retroperitoneal |
| 1934 | Sympathicoblastoma | Garofalo | 3 | - | - | Perirenal |
| 1934 | Sympathicoblastoma | Mosto and Echegaray | 6 | M | 3 yr. | Retroperitoneal |
| 1935 | Neurogenic sarcoma | Smith and Armstrong | 31 | M | - | Retroperitoneal |
| 1936 | Sympathicoblastoma | Wendel | 6 | F | - | Lumbar |
| 1936 | Neurinoma | I Vinogradov | 38 | F | - | Retroduodenal |
| | Neurinoma | I Vinogradov | 25 | F | 4 yr. | Perirenal |
| 1925 | Teratoma | Gordon | 50 | F | 3 mo. | Retroperitoneal |
| 1931 | Teratoma | Usandizaga and Mayor | 28 | F | - | - |
| 1932 | Teratoma | XIV Lundblad | 4 | F | - | - |
| | Teratoma | XV Lundblad | 4 | F | - | Lumbar |
| | Teratoma | XVI Lundblad | 25 | F | - | Pelviabdominal |
| 1932 | Teratoma | Froboese | 1/4 | F | 1 yr. | Retroperitoneal |
| 1934 | Teratoma | Watanabe | 2 | M | - | Retroperitoneal |
| 1934 | Chorionepithelioma | Fenster | 27 | M | 1 yr. | Lumbar |
| 1935 | Teratoma | Landivar and Iparraguirre | 45 | M | 3 mo. | Retrogastric |
| 1935 | Teratoma | Nicholson | 7 M | F | 5 mo. | Retroperitoneal |
| 1930 | Lymph cyst | Durst | - | - | - | Retroperitoneal |
| 1931 | Lymphangioma | Burlaneddin | 40 | M | 3 yr. | Retrocolic |
| 1931 | Sanguineous cyst | Shands | 49 | F | - | Retrocecal |
| 1934 | Lymphangioma | Kretschmer and Hibbs | 59 | F | - | Perirenal |
| 1935 | Hemangio-endothelioma | Steinert | 33 | F | - | Hepatic duodenal |
| 1935 | Sanguineous cyst | IV Rasmussen | 14 | F | - | Retroperitoneal |
| 1925 | Lymph cyst | Cornioley | 35 | F | - | Retrocecal |
| 1932 | Serous cyst | XIII Lundblad | M | 39 | - | Retroperitoneal |

NOTE.—Neither mesenteric tumors nor growths of the great omentum, unless secondary extending from a retroperitoneal site, have been included in the table.

In a recent case of a tumor presenting below the spleen, the pyelographic evidence could be interpreted as favoring renal origin. However, because of its intra-abdominal rather than lumbar location, I entered the abdomen by a transperitoneal paramedian incision. The mass proved to be a large solitary cyst of the lower pole of the left kidney developed mesial to the descending colon. Only when the intimate adherence of the cyst to the kidney parenchyma had been demonstrated, necessitating resection of part of the lower pole, was the point of origin determined.

A description of the differential diagnosis by means of x-ray will be found in Stepp and Böger.²²

Some of the larger growths show the transverse colon coursing over the anterior surface of the tumor in a well-formed gutter. More commonly the ascending or descending colon is crowded toward the median line. Only in centrally located growths does the large bowel surround the circumference of the growth, the small intestine being compressed upward or downward. In the retroperitoneal cyst which I previously described (Case 3), the entire abdominal content appeared lifted off

—CONT'D

| OPER. | RESULT | WEIGHT | |
|---------------------|------------------------------|--------------------|---|
| Exploratory | Recovered | Large | Incomplete operation; alive 1½ yr. postoperatively |
| Lumbar | Recovered | - | Recurrence with metastasis, 5 yr. postoperatively |
| Exploratory | Died 6 hr. | 2 kg. | Adherent to big vessels |
| Op. | Recovered | - | - |
| Exploratory | Died 4 mo. postoperatively | Large | Exploration for intestinal obstruction |
| Lap. | Recovered | Small | Well 2 yr. later |
| Op. | Recovered | - | Ecto- and mesoderm |
| Lap. | Recovered | 26 lb. | 2 germ layers-hair-bone-cysts; nephrectomy |
| Op. | Recovered | - | Mesodermal |
| Op. | Died | Large | Ecto- and mesoderm |
| Lumbar | Recovered | - | Died 8 mon. postoperatively, mainly entoderm |
| Lap. and parasacral | Died 11 days postoperatively | Large | Cerebral embolism; Polycystic ecto-, meso-, and entoderm |
| Autopsy | Died at 1¼ yr. | - | Between kidney and liver; mainly entoderm |
| Autopsy | Died | 660 gm. | Tridermal with carcinomatous metastases |
| Exploratory | Died | Large | Inoperable; testis in serial section normal |
| Lap. | Recovered | 1,750 gm. | Well 3 yr. postoperatively; 3 germ layers |
| Op. | Recovered | 2½ lb. | Ecto- and mesoderm; well 4¼ yr. postoperatively |
| Op. | Recovered | - | Well 1¼ yr. postoperatively |
| Op. | Recovered | 6.4 kg. | No follow-up |
| Op. | Recovered | - | - |
| Lumbar | Recovered | 8.5 by 11 by 9 cm. | Single flat layer endothelial cells |
| Lap. | Recovered | 7 cm. D. | Symptoms duodenal ulcer; well 6 mon. postoperatively |
| Lap. | Recovered | - | Well 16 yr. postoperatively; cyst without epithelial lining |
| Lap. | Recovered | 22 by 17 cm. | Epithelial lined |
| Lap. | Recovered | Very large | Inferior mesenteric artery in wall; died 11 yr. later from tuberculosis |

from the posterior abdominal wall. Pseudofluctuation, characteristic of lipomas and pseudomyxomas in females, regularly leads to the conclusion that an ovarian cyst is present. In my Case 2 pregnancy appeared to have been suspected before I saw the patient. Tuberculous peritonitis and hypernephroma are among the preoperative diagnoses.

In Froboese's case,²⁰ later demonstrated as a teratoma, Zondek¹⁰⁶ found a I and III gonadotropic reaction in the patient's urine. Similar reactions were obtained by Fenster²⁵ in a primary retroperitoneal chorioneplithelioma (serial sections of both testes normal).

Treatment.—Operation offers the surest prospect of permanent relief and cure. Andrews,² who reported 28 cases of retroperitoneal sarcoma from the Mayo Clinic in 1923, however, found that 20 of the 27 patients were already in an inoperable condition when first seen (sarcomas). In the older statistics the operative mortality was discouragingly high. Rosemann⁴⁴ found 25 to 38 per cent. Schmid,⁵⁷ of 133 cases operated upon between 1903 and 1922, noted a reduction of mortality to 7½

per cent. In the 107 cases collected by me, 99 are available in this connection as 8 were autopsy reports. Of the 98 patients operated upon, 18 died from the operation, an operative mortality of 18.4 per cent.

A marked difference in operative mortality is noted, depending upon the nature of the growth.

| | OPERATIVE MORTALITY |
|---------------------------------------|---------------------|
| Fibroma, lipoma, and cysts (28 cases) | 0% |
| Myxoma (11 cases) | 18.8% |
| Neurogenic (19 cases) | 22% |
| Sarcoma (38 cases) | 28.13% |
| Teratoma (8 cases) | 36.7% |

Both the operability and risk incurred depend partly upon the location, extent, adherence to, and involvement of vital or inaccessible structures; but the histology plays a more decisive role. In the older literature there is a report of Braun,¹¹ who resected 2 cm. of the aorta below the renal arteries, in the removal of a retroperitoneal growth, with survival of the patient. Nikolski²² reported a lateral tear of the vena cava, suture, recovery. In many instances the ureters or renal vessels were injured, necessitating nephrectomy. Injuries to the duodenum (Lundblad²⁵ Case IV), bladder (Dannheisser¹⁸), transverse colon (Bader⁵), and rectum (Krumbein²⁴) occurred during removal. Resection of the small intestine has been performed repeatedly. In a case of a mesenteric sarcoma, not reported in this series, Judd, Counsellor, and Hoerner⁴⁴ resected all but 30 cm. of the terminal ileum, the patient recovering. In retroperitoneal growths intestinal resection is most often necessitated by injury to, followed by ligation of, the inferior mesenteric, middle colic, or sigmoid vessels with resulting impairment of the vitality of the intestine.

The method of approach utilized has depended largely upon the pre-operative diagnosis or was based on the location of the mass. The majority of incisions have been paramedian, transperitoneal (84.6 per cent of 79 cases). For distinctly laterally located tumors a lumbar incision has been practiced, such as is used for kidney operations. This, when necessary, has been extended anteriorly. Frequently the lateral retroperitoneal approach has been converted into a transperitoneal one. Lundblad (Case XVI) performed a transperitoneal operation and completed the removal pararectally from below.

Härtel²³ has given a detailed anatomic description, well illustrated, of the anatomy of the posterior and lateral abdominal spaces as well as that of the attachment of the mesentery. In transperitoneal approach to the growth the apex of the tumor usually will present. As a rule the posterior peritoneum can be split over the most prominent part unless this endangers the blood supply of the small intestine or colon.

If the site is more lateral, the posterior peritoneal incision should be placed external to the ascending or descending colon, which may then be mobilized toward the midline. In a growth of the upper abdomen Kreiner⁵¹ found it necessary to incise and ligate the gastrocolic ligament. Through this approach he successfully detached a fibromyxosarcoma from the duodenum, posterior surface of the liver and diaphragm.

Cleavage planes should always be sought for. Deliberation, gentleness in handling tissues, careful search for ureters, inferior and superior mesenteric vessels, the great vessels of the abdomen, duodenum, pancreas, particularly the renal veins, will forestall injury to these important structures and thereby reduce the operative risk. It may be preferable, as I found in the case of schwannoma,²⁷ as well as Cases 2 and 3 here reported, temporarily to leave particles of tumor behind, with careful notation of their location, until the main mass has been delivered. The operative site is then so much more accessible that minute dissection of these residua is greatly facilitated.

In every instance, after the tumor has been removed, careful search for detached or completely separated growths must be instituted. As an example, the 15 additional lipomas found by Liebermann v. Wahlen-dorf may be cited. In my Case 2 the two large tumor masses were joined together below by an isthmus, in addition to which there was a small pedunculated growth attached to the left mass (Fig. 7). Kanjan and Krivoborskaja⁴⁸ found three unconnected tumors, soft fibromas of equal size, widely separated—left hypogastrium, presacral, and under the transverse mesocolon.

Reoperations for recurrences have been performed. Hosemann⁴¹ reported that, of seven cases operated upon twice, all died of recurrences. In my series, in addition to Hosemann's case, Quenu,⁸¹ Lundblad⁶³ (Case I), Burger and Osborne,¹² Lepoutre,⁶⁰ and Williams¹⁰³ operated two or more times. After a number of incomplete operations, patients have survived over varying periods of time. The treatment of these growths in some ways resembles that of pseudomyxoma peritonei, in which repeated operation may prolong life for many years. Lundblad, Case I,⁶³ performed five operations; the patient was alive six years after the last operation.

Radiotherapy, according to Lind⁶³ and also Hosemann,⁴¹ is useless for lipomas. It has proved, however, of service when inoperable conditions are encountered. Newton's⁷⁰ patient treated with radium needles inserted in the tumor (sarcoma) was well one year later. De Renzi's⁸⁴ case, a lipofibroma, was given x-ray treatments but died. Walters and Priestley's⁶⁹ case of sarcoma after operation and deep x-ray was well one year later. Kreiner's⁵¹ Case 1, a fibromyxosarcoma, was well one and one-half years. Adair's⁴ case of neurogenic sarcoma, merely explored, after x-ray was well two and one-half years. My own Case 1,

biopsy (mesenchymal), is well eight and one-half years after use of radium pack and deep x-ray; Case 2 received deep x-ray postoperatively and is well one and one-fourth years after operation. It appears well justified to give deep x-ray therapy postoperatively in this type of case.

Granulomas.—In Schiller-Christian disease large retroperitoneal granulomas may arise. Oberling⁷⁵ describes three cases successfully operated upon. In Case 2 the mass weighed 3 kg. Juhl¹⁷ encountered an apple-sized nonspecific granuloma between aorta and ascending colon in a 26-year-old female. Blaisdell,⁹ in the fatty tumor he removed (see Table I) noted hematopoiesis as in actively proliferating bone marrow. A similar condition may account for the 10 per cent eosinophilia described by Leichter.⁵⁹

SUMMARY

Primary retroperitoneal tumors, although unusual, occur with sufficient frequency to make it advisable for the surgeon to familiarize himself with the subject.

1. They develop retroperitoneally behind the intra-abdominal viscera. Mesenteric and omental growths are not included in this presentation.

2. The majority of the growths are of mesodermal origin (72 per cent). The remainder are of ectodermal (neurogenic, 18.7 per cent) or from totipotential germ cell derivation (teratomas, 9.3 per cent).

3. Tumors may attain huge size; those weighing up to 69 pounds have been reported. They may be solid, cystic, or a combination of both. With the exception of the round cell sarcomas, the majority are well encapsulated. Multiple, often unconnected masses are frequent and particularly in lipomas and myxomas account for "recurrences" if overlooked.

4. The histology shows benign lipomas, fibromas, and cysts; of doubtful clinical malignancy, myxomas; definitely malignant, sarcomas, neuroomas, and teratomas.

5. In the present series recurrences were noted in 14 (13 per cent); metastases, in 4 (3.7 per cent). In the older series 33 per cent metastases were found.

6. The clinical symptoms are not characteristic. Loss of weight and strength, an abdominal mass (central or lateral), and vague digestive disturbances are the rule.

7. Without operative intervention a fatal outcome from the increase in size and the pressure exerted may be anticipated even from benign growths.

8. Gastrointestinal x-ray and pyelography may aid in the diagnosis by excluding intrinsic intestinal and renal growths.

9. Depending on the sex, site, and associated symptoms, the preoperative diagnosis most often is that of fibroids, ovarian cysts, hypernephroma, tuberculous peritonitis.

10. Imperative indications for operation may arise if ileus, hydro-nephrosis or pyonephrosis, or intraperitoneal hemorrhage supervenes.

11. Operation offers the greatest prospect of cure. In the series of 107 cases, deducting the 8 autopsy reports, only 10 were found inoperable (10.1 per cent). Of these 10, 3 were alive 1 to 2½ years later after radium and x-ray treatment.

12. Transperitoneal approach was utilized in 66, lumbar or combined in 13, not stated in 19 cases.

13. The operative risk incurred depends mainly upon the histologic type of tumor. Mortality was zero in fibroma, lipoma, and cyst; it increased progressively in myxoma (18.18 per cent), neurogenic tumors (22 per cent), sarcoma (28.13 per cent), to teratoma (36.7 per cent).

14. Radiotherapy (radium pack, high voltage x-ray) is indicated in all inoperable or incompletely operated cases. It is recommended post-operatively except if fibroma or lipoma is encountered.

15. Three new cases are reported—embryonal mesodermal tumor (exploratory), radium pack and deep x-ray, well 8½ years; myxoliposarcoma, operated, postoperative x-ray, well 1¼ years; retroperitoneal cyst, marsupialized, well 6 years.

I desire to thank Dr. Sadao Otani for the photomicrographs appearing in this article.

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HYPERTROPHY OF THE LIGAMENTUM FLAVUM

WITH A REPORT OF TWO ATYPICAL CASES

J. M. MEREDITH, M.D., AND EDWIN P. LEHMAN, M.D., UNIVERSITY, VA.

(From the Departments of Neurological Surgery and of Surgery and Gynecology of the University of Virginia School of Medicine)

HYPERTROPHY of the ligamentum flavum with compression of the contents of the spinal canal has been rarely noted until recently. Spurling, Mayfield, Rogers¹ and Naffziger, Inman, and Saunders² have adequately discussed the etiology, the normal and pathologic anatomy, the usual symptomatology, and the treatment of the condition. The lesion is a simple hypertrophy of the ligament with no neoplastic or inflammatory element. In all probability, repeated stresses and strains, incident to heavy physical labor, constitute a factor in its production. The symptomatology is related both to local change in the spine and to compression of the dural contents. In all previously reported cases the involved ligament has been in the lumbar or lumbosacral area and a remarkably constant syndrome has been present, consisting of "pain low in the back with neurological signs of compression of the cauda equina," as pointed out by Spurling, Mayfield, and Rogers.¹

Two cases of the disease under consideration are made the subject of this report because of certain atypical pathologic and clinical features not hitherto recorded in this condition.* In each, the presence of an hypertrophied ligamentum flavum was demonstrated both grossly and microscopically.

CASE REPORTS

CASE 1.—Colored adult, male, admitted with pain in the back and legs and numbness of legs. No history of trauma. Complete block by Queckenstedt test. Cisternal lipiodol blocked at the fifth thoracic vertebral level. Laminectomy disclosed thickened ligamentum flavum. Discharged much improved. Second admission (nine months after discharge) with recurrence of symptoms. Queckenstedt test again demonstrated complete block. Reoperation advised and refused. Third admission (one month later), reoperation disclosed recurrence of the condition in the next highest ligament. Again discharged slightly improved. Sudden death from unknown cause at home two months after last operation. No autopsy.

George W. (University of Virginia Hospital, No. 103330), colored, aged 47 years, married, a laborer, was first admitted May 8, 1933, and discharged improved on June 29, 1933. He had been a steady drinker and smoker for many years. He was well until five weeks before admission when diffuse pain occurred, beginning in the back and radiating to the epigastrium and thorax. Three weeks before admission, weakness in the legs was noticed, increasing in severity until a cane was

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necessary to aid walking. Numbness of the legs began at the same time as the weakness. There was no sphincter disturbance.

On examination the deep tendon reflexes of the lower extremities were found to be exaggerated. There was an indefinite sensory level at the sixth thoracic dermatome. No sensory dissociation was present. There was loss of vibratory sensation in each leg together with moderate impairment of the sense of position. There was atrophy of each leg. Lumbar puncture showed an initial pressure of 60 mm. of water with a complete subarachnoid block.

The blood Wassermann was two plus. X-ray examination of the spine disclosed marked osteoarthritis between the anterior margins of the bodies of the eighth to the tenth thoracic vertebrae. Five days after admission, a combined lumbar-cisternal puncture was carried out which verified the previously demonstrated block and showed, in addition, increased globulin in the lumbar fluid. Iodized oil (0.75 c.c.) placed in the cisterna magna revealed a block at the fifth thoracic vertebral level after the patient had sat erect for two hours (Fig. 1).

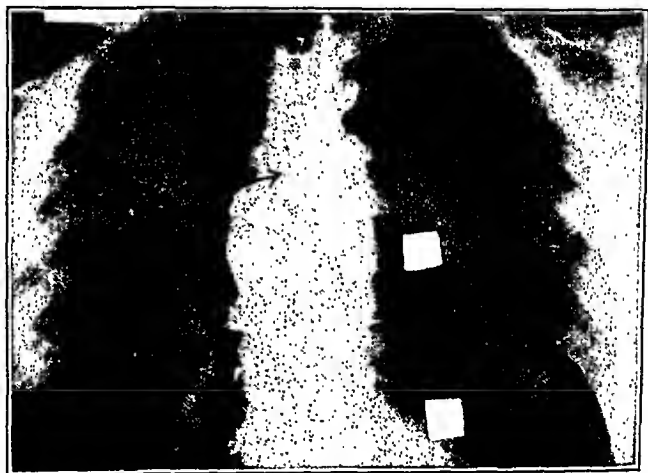


Fig. 1.—Case 1. Lipiodol (0.75 c.c.) introduced into cisterna magna revealing a complete subarachnoid block at the fifth thoracic vertebral level.

Ten days after admission, laminectomy was carried out (E.P.L.) under gas-oxygen anesthesia. An excerpt from the operative note reads: "The spines of the third to the sixth thoracic vertebrae were removed. The soft tissues appeared edematous and injected. The laminae were rongueured away from below upward. At the upper level of the fifth thoracic vertebra, a yellow mass was found lying over the dorsum of the dura. Additional bone was removed to a distance of 2 cm. above the lesion. The mass was 15 mm. in thickness. It was cartilaginous in consistency and attached to the periosteum. The tissue was bright yellow in color and was easily brushed away from the dura. The mass was dislodged from the lateral recesses and entirely removed, three-fourths of the circumference of the dura being involved. A curved impression in the dura resulting from the overlying mass was quite evident. The dura was not opened because of the possibility of the lesion being of an inflammatory nature. The dura was pulsating at the close of the operation below as well as above the site of the lesion."

The pathologic examination disclosed a mass of heavy fibrous tissue (Fig. 2). This was interpreted as normal ligamentum flavum although there was lymphocytic

infiltration about the vessels in the adventitiously included epidural fat, suggestive of syphilis. No tubercle bacilli were disclosed by special stains.

Three days after operation, there was noted considerable improvement in sensation, including sense of position and vibration in the lower extremities. Progressive improvement continued and he was discharged on June 29, 1933, forty-two days after operation. A follow-up letter six months after discharge stated that the patient was back at work as a laborer.

The patient was admitted for the second time on March 5, 1934, about eight months after discharge, and left the hospital on March 19, 1934, having refused operation. He stated that he had been making progressive improvement and was back at work at hard manual labor until one month previously when, after four hours of snowshoveling, numbness and weakness of the legs again suddenly supervened.

On examination, the patient was scarcely able to walk, even with the aid of crutches. There were no definite sensory changes found, although painful sensations and temperature appreciation in the legs were poorly detected by the patient. Position sense and vibratory sense in the lower extremities were practically absent.

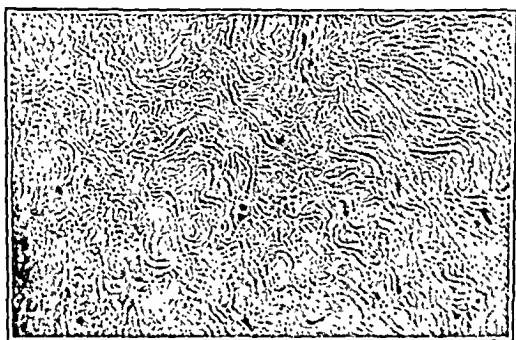


Fig. 2.—Case 1. Photomicrograph of elastic tissue removed at first operation of undoubted normal ligamentous structure ($\times 230$).

There was a suggestive ankle clonus on the right side but no Babinski sign could be elicited. The Romberg test showed considerable ataxia.

Lumbar puncture disclosed an initial pressure of 100 mm. of water. After the removal of 7 c.c. of fluid, the pressure was only 25 mm. of water. Complete subarachnoid block was again present. Examination of the fluid showed the presence of three-plus globulin, six lymphocytes, and a negative Wassermann reaction.

The patient was readmitted for the third time on April 6, 1934, eighteen days after the second discharge. At operation (E.P.L.) an hypertrophied ligamentum flavum was found at the fourth thoracic vertebral level and below this area a marked amount of extradural inflammatory tissue was disclosed. As much of this tissue as possible was removed. The dura was opened and marked arachnoiditis and injection of the cord were seen, to be ascribed, probably, to the lipiodol injected prior to the first operation. No resistance was met to the passage of a blunt instrument up and down the subarachnoid space.

Pathologic examination of the tissue removed at the second operation disclosed fragments of necrotic bone embedded in what appeared to be typical tuberculous granulation tissue. It was composed of small, often confluent, nodules of epithelial cells, among which were numerous giant cells; in addition, numerous small areas of caseation were seen. The whole tissue was infiltrated by lymphocytes. (Fig. 3.) A

necessary to aid walking. Numbness of the legs began at the same time as the weakness. There was no sphincter disturbance.

On examination the deep tendon reflexes of the lower extremities were found to be exaggerated. There was an indefinite sensory level at the sixth thoracic dermatome. No sensory dissociation was present. There was loss of vibratory sensation in each leg together with moderate impairment of the sense of position. There was atrophy of each leg. Lumbar puncture showed an initial pressure of 60 mm. of water with a complete subarachnoid block.

The blood Wassermann was two plus. X-ray examination of the spine disclosed marked osteoarthritis between the anterior margins of the bodies of the eighth to the tenth thoracic vertebrae. Five days after admission, a combined lumbar-cisternal puncture was carried out which verified the previously demonstrated block and showed, in addition, increased globulin in the lumbar fluid. Iodized oil (0.75 c.c.) placed in the cisterna magna revealed a block at the fifth thoracic vertebral level after the patient had sat erect for two hours (Fig. 1).

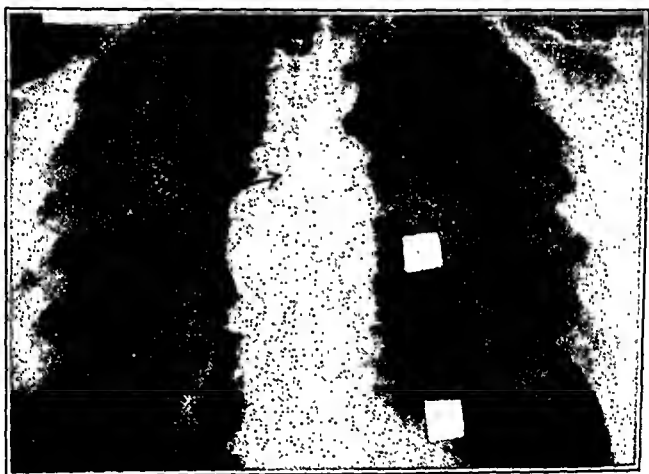


Fig. 1.—Case 1. Lipiodol (0.75 c.c.) introduced into cisterna magna revealing a complete subarachnoid block at the fifth thoracic vertebral level.

Ten days after admission, laminectomy was carried out (E.P.L.) under gas-oxygen anesthesia. An excerpt from the operative note reads: "The spines of the third to the sixth thoracic vertebrae were removed. The soft tissues appeared edematous and injected. The laminae were rongeured away from below upward. At the upper level of the fifth thoracic vertebra, a yellow mass was found lying over the dorsum of the dura. Additional bone was removed to a distance of 2 cm. above the lesion. The mass was 15 mm. in thickness. It was cartilaginous in consistency and attached to the periosteum. The tissue was bright yellow in color and was easily brushed away from the dura. The mass was dislodged from the lateral recesses and entirely removed, three-fourths of the circumference of the dura being involved. A curved impression in the dura resulting from the overlying mass was quite evident. The dura was not opened because of the possibility of the lesion being of an inflammatory nature. The dura was pulsating at the close of the operation below as well as above the site of the lesion."

The pathologic examination disclosed a mass of heavy fibrous tissue (Fig. 2). This was interpreted as normal ligamentum flavum although there was lymphocytic

On examination, he was found to walk with a toedrop gait. There was marked bilateral weakness of the peronei and anterior tibial muscles. The calves of the legs were large and the muscles were soft and boggy. There was no sensory disturbance in any modality, and no pain in the back or in the legs was present. The knee jerks and the ankle jerks were absent. No pathologic reflexes could be elicited. The blood Wassermann and Kahn both were negative. X-ray films of the lumbo-dorsal spine were normal.

Three days after admission, lumbar puncture showed a protein content of 430 mg. per cent and three lymphocytes in the spinal fluid. The Queckenstedt test showed no subarachnoid block.

Iodized oil was injected into the cistern, and in the region of the third lumbar vertebra a small constant lateral filling defect was seen (Fig. 4) corresponding to the appearance reported in cases of localized extradural masses encroaching on the spinal canal.^{2, 3}



Fig. 4.—Case 2. Lipiodol injection (cistern) showing a small irregularity at L₃ vertebral level (arrow) consistent with an extradural lesion.

Laminectomy on May 31, 1937 (Dr. William Hill), revealed, at the level of the third lumbar vertebra, a dense yellow ligamentous band running transversely across the dura. Above this area there was a bulging of the epidural fat. The constricting band was divided, dissected back on either side and excised. The dura and arachnoid were then opened and the lipiodol removed. There was no evidence of tumor and no projection into the canal in the region of the intervertebral disk.

Microscopic examination of the removed tissue showed a typical ligamentous structure consisting of uniformly dense fibrous tissue, containing few cells (Fig. 5).

The patient made an uneventful convalescence. He was discharged thirteen days postoperatively with the wound well healed. There was no essential change from his preoperative neurological status.

few characteristic acid-fast bacilli were demonstrated in the caseous areas. Attached to one of the masses of granulation tissue was a thick layer of dense, collagenous fibrous tissue. There were also several small masses of elastic tissue which showed no pathologic changes. *Diagnosis:* Ligamentum flavum; tuberculous granulation tissue; fragments of necrotic bone.

The patient was discharged thirty-four days after operation, being able to move his legs fairly well and walking with support. There was improvement in pain appreciation and in heat and cold discrimination in the legs. Vibratory sense of the lower extremities was still diminished. These findings were interpreted as showing improvement over the preoperative status at the time of the third admission. Antisyphilitic therapy was carried out, postoperatively, before the patient was discharged.

He became suddenly ill and died in a few days, about a month after final discharge from the hospital and over two months following the second operation. Details of his final illness are not known and no post-mortem examination was possible.



Fig. 3.—Case 1. Photomicrograph of tissue removed at second operation. Dense fibrous tissue of the ligamentous type is seen. The central lesion (arrow) is suggestive of a chronic granulomatous infection, superimposed on hypertrophy of the ligament ($\times 120$). (Tubercle bacilli were found by carbol-fuchsin stain.)

CASE 2.—White adult, male, admitted complaining of weakness of the legs of three months' duration without pain or sensory disturbance. X-ray examination after iodized oil injection showed a filling defect at L₅ vertebral level. Markedly increased globulin content of cerebrospinal fluid. Laminectomy disclosed hypertrophy of the ligamentum flavum. Dura opened. No evidence of tumor. On discharge thirteen days postoperatively, no essential change in neurological findings.

Carl D. (University of Virginia Hospital, No. 131682), white, aged 23 years, married, a rayon mill worker, was admitted May 17, 1937, and discharged June 13, 1937. His chief complaint was weakness of the legs of three months' duration. Eleven months before admission he had noticed weakness of his knees after jumping across a creek. For the last three months, there had been a slowly progressive weakness of the lower extremities. A lumbar puncture performed a few days before admission revealed 130 mg. of protein per 100 c.c. of spinal fluid.

TABLE I

SUMMARY OF 23 TYPICAL CASES RECORDED IN THE LITERATURE TO DATE (INCLUDING 2 CASES FROM THIS CLINIC) TO SHOW SIMILARITY OF FINDINGS*

| | |
|-----------------------------------|--------------------|
| <i>Age.</i> — | |
| Extremes | 16-59 yr. |
| Average | 36.6 yr (22 cases) |
| <i>Sex.</i> — | |
| Male | 18 cases |
| Female | 5 cases |
| <i>History of Trauma.</i> — | |
| Direct | 1 case |
| Indirect | 15 cases |
| No history | 7 cases |
| <i>Symptoms.</i> — | |
| Pain in back or legs | 23 cases |
| Weakness of legs | 12 cases |
| Sphincter disturbance | 1 case |
| Impotence | 3 cases |
| <i>Signs.</i> — | |
| Hyperesthesia | 14 cases |
| Hypesthesia | 15 cases |
| Anesthesia | 7 cases |
| Motor weakness | 14 cases |
| Absent or diminished ankle jerks | 15 cases |
| Atrophy | 6 cases |
| <i>Queckenstedt Test.</i> — | |
| Normal | 15 cases |
| Block demonstrated | 3 cases |
| Not done or not recorded | 5 cases |
| <i>Spinal Fluid Protein.</i> — | |
| Normal | 2 cases |
| Elevated (above 45 mg. per cent) | 13 cases |
| Not recorded | 8 cases |
| <i>Lipiodol.</i> — | |
| Defect or block | 18 cases |
| Not reported or not done | 5 cases |
| <i>Location.</i> — | |
| Lumbar spine | 17 cases |
| Lumbosacral spine | 6 cases |
| <i>Postoperative Course.</i> — | |
| Relieved | 19 cases |
| Slight residual pain or weakness | 2 cases |
| Recurrence | 1 case |
| Postoperative deaths (meningitis) | 1 case |

*Elsberg,⁶ 1 case; Towne and Reichert,⁵ 2 cases; Puusepp,¹ 3 cases; Abbott,³ 1 case; Spurling, Mayfield, and Rogers,¹ 7 cases; Brown,⁹ 7 cases; Meredith and Lehman (see Supplementary Note), 2 cases.

of symptoms been noted* and in none has tuberculous granuloma, or, in fact, any inflammatory tissue, been found.

There is no question that the mechanical conditions found in the cases reported elsewhere were present in Case 1 of this report, including direct evidence of subarachnoid block and an increased spinal fluid globulin. When the lesion was first uncovered, it resembled in detail the lesion described by Towne and Reichert,⁵ and when it was removed not only was the mark of constriction obvious, but removal was followed

*Spurling¹ reports mild recurrence of pain in one case after the date of publication of his paper.¹

The patient reported two months after operation. He had experienced slight improvement. Examination showed no neurological abnormalities above the pelvis, except diminished left abdominal reflexes. The motor power of the legs, knees, and hips was fairly good, the patient being able to walk quite well without a cane. There was almost complete bilateral footdrop. Skin sensation was intact throughout. Position sense was normal, but vibratory sense was greatly diminished in each foot. There was no sphincter disturbance. The knee jerk was absent on the left and markedly diminished on the right. No ankle jerks were elicited. In the Romberg position the patient swayed markedly, probably because of poor control of the feet. Dorsiflexion of the feet was impossible.

When last seen, about seven months after operation, his condition was essentially unchanged as compared with his condition five months previously. The patient stated that, although his disability had been steadily progressive before the operation, it has been stationary since. He was referred to the Orthopedic Department for treatment of the footdrop.

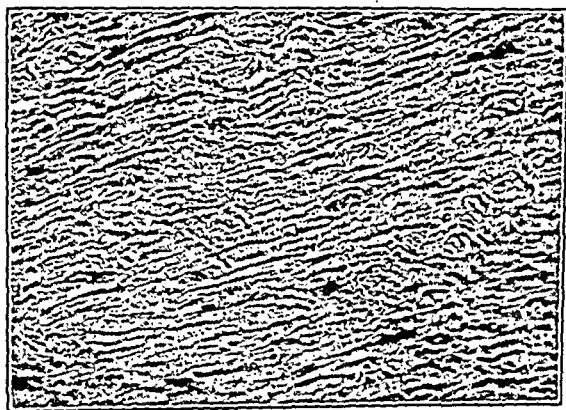


Fig. 5.—Case 2. Photomicrograph of lesion removed at operation. Typical fibroelastic structure of ligamentum flavum ($\times 600$).

COMMENT

The two cases here presented are atypical as compared with the justifiable generalizations of Spurling and his colleagues¹ based on the manifestations of previously observed cases. (For summary of typical findings in other cases see Table I.) In Case 1 the location of the lesion in the thoracic region is unique, inasmuch as in all other cases, including Case 2 of this report, the lesions occurred in the lumbar or lumbosacral region. Case 1, in addition, after an apparent operative cure, showed a complete return of disability and was found to have a similar lesion at a level one vertebra above the original site. The recurrence in this area was associated with a marked extradural development of tuberculous granulation tissue, although sections of the original lesion revealed no evidence of inflammation (Fig. 2). In no previous case has recurrence

trophy of the ligamentum flavum with atypical neurological findings. If so, it also represents an important addition to our knowledge of this unusual condition.

The atypical site, course, and neurological behavior illustrated by the two cases herein reported suggest that knowledge of hypertrophy of the ligamentum flavum is yet too undeveloped to enable one to place entire reliance on the rather characteristic picture heretofore described. It is desirable that all unusual instances of the disease be reported in detail. It is only on the basis of a much larger series of cases that a final perspective of this condition can be obtained.

SUPPLEMENTARY NOTE

The following two cases of the typical syndrome of hypertrophy of the ligamentum flavum, as described by previous observers, have been seen during the past year in this Clinic. These are here reported not only as a contrast to the cases recorded above, but also to complete the literature of a rare condition.

CASE 1.—White adult, aged 37 years, male. Pain in the right hip, thigh, and leg of six months' duration. No direct trauma to back; patient is a truck driver. Lost seven pounds of weight in four weeks before admission. Totally incapacitated for work.

Examination: Ankle jerks unobtainable. No numbness to pinprick. Atrophy of muscles in right calf. Lumbar curve kyphotic. No muscle weakness.

Queckenstedt (L_{4-5}) normal. Fluid faintly xanthochromic. Spinal fluid protein: 100 mg. per cent; 4.5 c.c. descending lipiodol showed typical defect in oil column at L_{4-5} interspace on right side. Laminectomy (L_4 to S_1): Hypertrophied ligamentum flavum found and removed (7 mm. thick). Microscopically verified. Uneventful recovery. Follow-up examination (two months after operation): much improved. Gained eleven pounds in weight. Severe pain in right hip and leg has disappeared. Gait erect and brisk. Back at work as a truck driver.

CASE 2.—Colored adult, aged 42 years, male. Pain in lower back and left leg, intermittently, for three years. Four months before admission had sudden pain in back while lifting a heavy log. Patient is a day laborer. Excessive use of sedatives. Totally incapacitated for work.

Examination: Ankle jerks unobtainable. Hyperesthesia to pinprick in left thigh, hip, and leg. Atrophy of left calf. Severe pain on palpation of left sciatic nerve in thigh. No weakness of legs or footdrop. No incontinence.

Queckenstedt (L_{4-5}): slight subarachnoid block. Slight xanthochromia. Spinal fluid protein: 225 mg. per cent. Blood Wassermann four plus. Five cubic centimeters lipiodol (descending) showed typical defect at L_5 to S_1 interspace on left side. Laminectomy (L_5 to S_1): hypertrophied ligamentum flavum found and removed (1.0 cm. thick). Microscopically verified. Uneventful recovery. Follow-up examination (seven weeks after operation): complete arrest of symptoms.

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by practically complete, although not permanent, recovery. Furthermore, the histologic picture, except for slight evidence of perivascular inflammation in the epidural fat, was comparable to the histologic picture illustrated in their paper and resembled closely the appearances seen in the study of a normal ligament (Fig. 2). In other words, except for the location, the pathology of the lesion in this case at the onset was identical with that of other reported cases. At the time of first discharge, there was no hesitation in making a definite diagnosis of hypertrophy of the ligamentum flavum.

The later findings led to some doubt as to the identity of this case with others reported, largely because of the definitely tuberculous nature of the tissue removed at the second operation. Variation from the typical neurological picture is explained here, of course, by the fact that the spinal cord rather than the cauda equina was subjected to compression.

The pathogenesis of the cases heretofore recorded is obscure, although trauma seems to play a part. The unusual behavior of this case (Case 1), particularly the appearance of tuberculous granulation tissue between the first and second operations and the positive blood Wassermann, offer confusing elements which in this case might be associated with the origin of the lesion under consideration. The relationship of syphilis or tuberculosis to this particular case must remain unsettled.

The striking variation in Case 2 from the typical manifestations of the disease lies in the neurological findings. As contrasted with all other cases, including Case 1 of this report, this patient was free from pain. The chief complaint and the neurological findings were almost entirely motor, consisting of muscle weakness, particularly in dorsiflexion of the feet. Although almost two-thirds of the typical cases reported (Table I) presented some motor weakness, it was in no case the presenting symptom and was always associated with marked afferent phenomena. The only sensory disturbance in this case was some loss of vibratory sense. Both gross and microscopic pathologic findings in the excised ligament were typical (Fig. 5), including the site of occurrence. In addition, the x-ray demonstration of a lateral defect in the shadow of the iodized oil corresponded exactly to the appearances reported in other cases. An elevated cerebrospinal fluid protein below the defect also suggested the typical mechanical derangement.

The failure to obtain neurological relief following the surgical removal of the ligament also makes Case 2 unusual. It is possible that an undiscovered cause for the muscle weakness might still be present. It seems unnecessary, however, to make such an assumption in the presence of a known lesion which could be responsible for neurological changes in the motor nerves involved. It is probable that this case represents hyper-

SUBCUTANEOUS INJURIES OF THE INTESTINE AND MESENTERY

H. P. TOTTEN, M.D., LOS ANGELES, CALIF.

(From the Department of Surgery of the University of Southern California)

THE subject of subcutaneous injuries of the abdominal viscera is assuming major importance in the list of acute surgical emergencies because of the rapidly increasing number of automobile accidents.

This paper proposes to deal with those cases of trauma in which paramount injury was sustained by the intestine or its mesentery. Special emphasis will be placed upon a discussion of those factors which influence the mortality rate. However, for a clear understanding of the subject, it is necessary to consider the mechanism of injury and the signs and symptoms which are important in diagnosis.

This report is based upon an analysis of 25 cases of perforation of the intestine or tear of the mesentery from the surgical wards of the Los Angeles County Hospital Unit 1. In this series there were 14 deaths, a mortality of 56 per cent. The fatal group included 9 cases that were not operated upon. There were 5 deaths in the 16 operative cases, a mortality of 31 per cent.

The trauma responsible for this type of injury may be direct violence, indirect violence, or muscular action.¹⁴ The greatest number are probably due to direct violence which may be subdivided into generalized or local trauma. According to the classification of Moty,¹¹ there are three modes of rupture: (1) The intestine (or its mesentery) may be crushed. (2) The intestine (or its mesentery) may be torn. (3) The intestine may burst because of pressure within its lumen.

In crushing injuries compression may be accomplished by one vulnerating body when an intestinal coil is caught between the traumatizing object and the vertebral column, or the abdomen may be compressed between two objects. When traction is made upon the intestine and mesentery by the application of force at a tangent with the abdominal wall, a tearing injury will result. Explosive or bursting ruptures occur from sudden rise of pressure within the lumen of the intestine when the pressure exceeds the limit of elasticity of the intestinal wall.

According to John,⁷ rupture may occur by indirect violence when a person falls, landing on his feet or buttocks with the trunk in an upright position so that the sudden stop causes the intestine, by its own weight, to jerk violently against its mesenteric attachment and so cause tearing.

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Muscular effort alone, as a cause of intestinal rupture, is the subject of an article by Wilensky and Kaufman.¹⁶ They call attention to the high incidence of hernias in the series of cases they report gathered from the literature. It seems evident that the frequency of hernia in this type of bowel rupture is quite significant. Aird,¹ likewise, stresses the importance of hernias associated with subcutaneous intestinal rupture. He states that rupture may be due to violence applied directly to the hernia, to direct abdominal injury, or, more rarely, to violent hyperextension of the trunk. Vance¹⁷ believes that the hernia sac aids the production of this lesion because the coverings of the sac are too weak to support the intestinal wall against the explosive force within its lumen.

SYMPTOMS AND SIGNS

The price of early diagnosis must be constant alertness to suspect intra-abdominal injury in the presence of severe general trauma, whether or not there is a history of direct abdominal trauma.

The clinical picture in the early stages when the trauma has been severe, especially with associated extra-abdominal injuries, is one of shock. Extra-abdominal injuries with severe shock overshadowed the abdominal injury and caused diagnostic error in four cases in this series. On the other hand, as Cooke states:⁴ "In the presence of slight general trauma, rupture of the intestine may produce few immediate symptoms."

Occasionally, delay in onset of symptoms may be due to secondary perforation of the bowel, the original lesion at the time of accident being a bruise of the intestinal wall, which later sloughs with the onset of symptoms of perforation. In one case in this series contusion of the bowel wall was sufficient to devitalize the tissue to the extent that it became permeable to the passage of bacteria with the development of generalized peritonitis.

A careful consideration of the history with reference to the type of injury sustained, together with a careful physical examination and close observation over a period of three or four hours, will lead, at least, to a definite suspicion of intra-abdominal injury which is adequate justification for operation.

It is remarkable that, even in the presence of extreme violence, there is usually little evidence of injury to the abdominal parietes. There was evidence of trauma to the abdominal wall in only 8 of 25 cases. Abrasions and bruises were the most common injuries. The only instance in this series of severe injury was a case of traumatic hernia, in which all layers of the abdominal wall were ruptured except the skin.

Evidence of injury to abdominal parietes in 25 cases of intestinal and mesenteric injury:

| | |
|--|--------|
| 1. Abrasion across upper abdomen and lower ribs | 1 case |
| 2. Imprint of horseshoe above symphysis on right side | 1 case |
| 3. Abrasion of skin over splenic area | 1 case |
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| 6. Superficial abrasion along right costal margin | 1 case |
| 7. Abrasion of lower abdomen | 1 case |
| 8. Abrasion above umbilicus | 1 case |

PAIN

Pain is present to a degree in all cases. When constant and increasing in severity, it is the most reliable symptom in diagnosis. Pain was recorded as severe or intense in 11 instances, moderate in 9, and slight in 2. In 3 patients that were moribund on admission, the presence or absence of pain was not recorded. In 3 cases of mesenteric injury, associated with much free blood in the peritoneal cavity, shoulder pain was present.

TENDERNESS AND RIGIDITY

The presence of tenderness and rigidity in this series was quite constant. Tenderness, as a rule, is quite diffuse, with frequently a localized area of maximum intensity over the site of injury. Without escape of intestinal contents or intraperitoneal hemorrhage, the tenderness may be quite moderate and well localized.

Tenderness of the pelvic peritoneum, demonstrated by rectal examination, is an important diagnostic sign, indicating, in early cases, the presence of blood, or rarely, free intestinal contents. Later it may indicate the extension of peritonitis to the pelvis.

Although in the rare exception, rigidity may be absent; it may be safely stated that this symptom is the most constant and valuable physical sign in the examination of the abdomen. Like tenderness, it is more often generalized, with a local area of maximum intensity. Absence of muscular rigidity may be found in those cases of contusion of the bowel without primary rupture or hemorrhage, occasionally in cases with profound shock, and rarely in late cases with well-developed peritonitis and profound toxemia in which meteorism predominates.

| | |
|---------------------------------|----|
| Cases with generalized rigidity | 20 |
| Cases with local rigidity only | 2 |
| Cases without rigidity | 3 |

Cope⁵ stresses the value of muscular rigidity as an important symptom, especially where it persists over a period of a few hours, as that due to simple contusion of the muscles tends to pass off within a comparatively short period of time.

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| Cases without rigidity | 3 |

Cope² stresses the value of muscular rigidity as an important symptom, especially where it persists over a period of a few hours, as that due to simple contusion of the muscles tends to pass off within a comparatively short period of time.

Muscular effort alone, as a cause of intestinal rupture, is the subject of an article by Wilensky and Kaufman.¹⁶ They call attention to the high incidence of hernias in the series of cases they report gathered from the literature. It seems evident that the frequency of hernia in this type of bowel rupture is quite significant. Aird,¹ likewise, stresses the importance of hernias associated with subcutaneous intestinal rupture. He states that rupture may be due to violence applied directly to the hernia, to direct abdominal injury, or, more rarely, to violent hyperextension of the trunk. Vance¹⁵ believes that the hernia sac aids the production of this lesion because the coverings of the sac are too weak to support the intestinal wall against the explosive force within its lumen.

SYMPTOMS AND SIGNS

The price of early diagnosis must be constant alertness to suspect intra-abdominal injury in the presence of severe general trauma, whether or not there is a history of direct abdominal trauma.

The clinical picture in the early stages when the trauma has been severe, especially with associated extra-abdominal injuries, is one of shock. Extra-abdominal injuries with severe shock overshadowed the abdominal injury and caused diagnostic error in four cases in this series. On the other hand, as Cooke states:⁴ "In the presence of slight general trauma, rupture of the intestine may produce few immediate symptoms."

Occasionally, delay in onset of symptoms may be due to secondary perforation of the bowel, the original lesion at the time of accident being a bruise of the intestinal wall, which later sloughs with the onset of symptoms of perforation. In one case in this series contusion of the bowel wall was sufficient to devitalize the tissue to the extent that it became permeable to the passage of bacteria with the development of generalized peritonitis.

A careful consideration of the history with reference to the type of injury sustained, together with a careful physical examination and close observation over a period of three or four hours, will lead, at least, to a definite suspicion of intra-abdominal injury which is adequate justification for operation.

It is remarkable that, even in the presence of extreme violence, there is usually little evidence of injury to the abdominal parietes. There was evidence of trauma to the abdominal wall in only 8 of 25 cases. Abrasions and bruises were the most common injuries. The only instance in this series of severe injury was a case of traumatic hernia, in which all layers of the abdominal wall were ruptured except the skin.

Evidence of injury to abdominal parietes in 25 cases of intestinal and mesenteric injury:

was first described by G. A. Peters of Toronto in a paper entitled "The Telephonic Properties of the Inflamed Abdomen" in the *Canadian Journal of Medicine and Surgery*, December, 1902. It was reported again by Claybrook³ in 1904. The latter author considered it a positive indication for laparotomy whether other signs are present or not and believed it due to irritation of the parietal peritoneum by the sudden outpouring of foreign material into the abdominal cavity. He noted the sign in cases of ruptured solid viscera with hemorrhage as well as in cases of ruptured hollow viscera with free air. Ledgard⁸ believed the phenomenon was due to gas in the peritoneal cavity as he did not think the presence of free fluid alone was enough to produce the sign. I, however, have observed the sign in the case of rupture of solid as well as hollow viscera, but I am not prepared to venture an opinion as to its value as a frequent diagnostic sign.

OBLITERATION OF LIVER DULLNESS

Diminution or obliteration of liver dullness is not a frequent sign of early perforation of the intestine. Certainly it is not found as frequently in traumatic rupture of the bowel as in acute perforation of peptic ulcer. Absence of liver dullness may indicate a late stage of peritonitis' being caused by ileus and, consequently, in such instances, is a bad prognostic sign. In this series obliteration of liver dullness was found in 2 cases, 1 of which was due to tympany from distended bowel in a well-advanced peritonitis.

X-RAY

Positive findings in the flat x-ray plate of the abdomen are diagnostic. The presence of free air, intestinal contents, and blood may be demonstrated by this method. As a positive finding its value is obvious, but negative findings should not influence one's decision. Only 1 case in this group, a rupture of the jejunum, was x-rayed with reference to the demonstration of free air. The findings were negative. Greater use should be made of this valuable diagnostic method in doubtful cases for, although the percentage in which free air will be demonstrated is probably small, yet those in which free intestinal contents and blood may be shown will raise the number with positive x-ray findings considerably.

TEMPERATURE AND PULSE

During the initial period of shock, a subnormal temperature and weak thready pulse are to be expected. Following this period, these two indicators are not a reliable guide as they are apt to be normal. However, an abnormality consisting of a gradual but steady increase in pulse rate and temperature is considered of great diagnostic importance. Unfortunately, these are comparatively late signs and to wait for them

VOMITING

Vomiting is significant, especially when repeated and continuous. However, it is not invariably present. It was absent in 3 cases in this series in which the trauma was localized and pathologic lesion was confined to the intestine. Moynihan¹² stated that vomiting, with a continuous increase of pulse rate after the period of shock is over, were two signs together which justified exploration.

SHIFTING DULLNESS

The presence of free fluid in the peritoneal cavity, as denoted by shifting dullness in the flanks, is a positive sign of intraperitoneal injury that calls for operative intervention. During the first few hours following rupture, contraction of the muscular coats of the intestinal wall usually prevents the escape of contents in an amount large enough to be detected by abdominal percussion except with large or complete tears. However, with tearing of mesenteric vessels or, more rarely, vessels in the bowel wall itself, bleeding sufficient to give dullness in the flanks will occur. There were 8 cases in which shifting dullness in the flanks was demonstrated. In 2 cases it was due to massive escape of intestinal contents from large tears of the bowel and in the remaining 6 it was due to hemorrhage from the mesentery, from the bowel wall, from a solid viscus, or from a combination of these sources.

| | |
|---------------------------------|----------|
| Presence of shifting dullness | 8 cases |
| Absence of shifting dullness | 3 cases |
| No mention of shifting dullness | 14 cases |

COMPLETE ABSENCE OF AUDIBLE PERISTALSIS (SO-CALLED
"SILENT ABDOMEN")

Too much reliance should not be placed on this sign. It is true, in the majority of cases, that audible peristalsis is absent following perforation of a hollow viscus, but in the occasional instance it may be present and even active. It is well to remember in this connection that audible peristalsis may be absent in the normal peritoneal cavity for a period of time which exceeds that ordinarily consumed in auscultation of the abdomen. In such cases, however, it may usually be elicited by mildly stimulating the abdominal wall by blunt stroking or pressure with quick release.

| | |
|-----------------------------------|----------|
| Audible peristalsis absent | 8 cases |
| Audible peristalsis present | 1 case |
| Audible peristalsis not mentioned | 16 cases |

CLAYBROOK'S SIGN

The transmission of the heart and respiratory sounds so that they can be heard almost as well all over the abdomen as over the chest

Laceration of the Mesentery.—When a tear of the mesentery occurs with bleeding of any considerable quantity, the specific sign of free intraperitoneal fluid, shifting dullness in the flanks, is present. Eleven of 12 cases of mesenteric tear were due to automobile accidents. The 1 exception was that due to indirect violence. Five of these 12 were associated with intestinal perforation. Of the remaining 7, 1 was associated with severe bruising, but not rupture of the bowel wall. In this group of 7, unassociated with bowel rupture, only 1 was operated upon. This case was unassociated with any other injury and recovery took place. All of the remaining 6 died. They were all associated with other injuries. Four were complicated by fractures; 1, by rupture of the liver and kidney; and 1, by severe bruising of the bowel wall. The reason for not operating upon these 6 patients was because of diagnostic error in 3 and moribund condition of the patient in 3. The cause of death in each case was due, essentially, to hemorrhage, although shock was a contributing factor in 2 and peritonitis in 2.

It should be remembered that the danger of mesenteric tears is two-fold. Hemorrhage is probably the most frequent cause of death. However, fatal peritonitis may result from devitalization or sloughing of the bowel wall deprived of adequate blood supply. A rare but highly fatal complication is "mesenteric disinsertion," or complete tearing of the mesentery from the bowel for variable distance. This condition, as well as mesenteric injuries of lesser magnitude in which the viability of the bowel is jeopardized, necessitates intestinal resection.

Associated Intraperitoneal Injury.—There were only 2 cases of associated intraperitoneal injury; a rupture of the liver (and kidney) occurred in a case of torn mesentery and a ruptured pancreas occurred with a rupture of the duodenum.

Associated Extraperitoneal Injury.—This group is instructive. There were 8 cases, 7 of which were fractures. Six of these were not operated upon, 3 because of erroneous diagnoses and 3 because of moribund condition of patient on admission. Four of these fracture cases occurred with mesenteric injuries, without intestinal rupture.

This group forms an important one. Because of the increased number of automobile accidents, the relative and actual incidence of these cases is becoming greater. They are poor surgical risks because of shock and hemorrhage. Hemorrhage from a large mesenteric vessel may be rapidly fatal, especially when combined with shock from a major fracture. The diagnosis may be masked by an obvious injury, while the intra-abdominal pathology is overlooked even with severe intraperitoneal hemorrhage. This chance is increased by the fact that evidence of abdominal trauma in the form of abrasions or other evidence of external injury may be, and usually is, quite insignificant.

In order that these cases may not be overlooked, abdominal injury should be suspected in every case of severe general trauma, whether or

may be to wait until the pathologic process has progressed too far. Following the period of shock, a steadily increasing pulse rate with a falling blood pressure is indicative of hemorrhage.

THE BLOOD COUNT

Because of the associated shock with a depletion in plasma volume, the red cell count in the early hours of bowel perforation will tend to be normal, even with considerable hemorrhage. The leucocyte count is characteristically elevated in part because of decrease in plasma volume and in part because of stimulation to the peritoneum. The red cell count, taken in 7 cases, ranged from 2,600,000 to 5,500,000 with 6 well above 4,000,000. The low count occurred in a case of extreme retroperitoneal and intraperitoneal hemorrhage associated with a fractured pelvis. Leucocytosis was found in all except 1 of 14 cases, ranging from 6,800 to 32,200, the latter occurring in a case of ruptured mesentery without other injury.

Emphysema of the posterior abdominal wall is a diagnostic sign of retroperitoneal rupture of the duodenum or colon. Butler² calls attention to the fact that emphysema of the pelvic cellular tissues may be palpated on rectal examination. In this series the sign was not observed.

FACTORS WHICH INFLUENCE THE MORTALITY RATE*

Nature of the Traumatizing Force.—Automobile accidents were responsible for 17 cases, with a mortality of 65 per cent. The remaining 8, with a mortality of 37 per cent, were due to a variety of accidents, but with a common factor, 1 case excepted, of well-localized trauma applied to the abdomen. The one exception occurred in a patient who jumped from a window, presumably in which case the violence was indirect.

The high mortality rate in the group caused by motor car accidents is due to the greater degree of violence and its wider application with serious associated injuries. There were 9 instances of associated extraperitoneal injury and 2 of intraperitoneal injury, all of which occurred in those due to automobile accidents. There were 3 instances of automobile injuries in which the trauma was localized, due to the steering wheel striking the abdomen.

Location of Intestinal Perforation.—The ileum was the site of perforation in 10 cases, with a mortality of 20 per cent. Seven were unassociated with other injury, not including the mesentery. Six were due to localized trauma. There were 5 cases of perforation of the jejunum with 3 deaths, a mortality of 60 per cent. Two cases of rupture of the duodenum and 1 case of rupture of the descending colon were fatal.

*See Table I.

TABLE I

| SEX | AGE | NATURE OF TRAUMATIZING FORCE | LOCATION OF INTESTINAL RUPTURE | TEAR OF MESENTERY | ASSOCIATED INTRAPERITONEAL INJURY | ASSOCIATED EXTRAPERITONEAL INJURY | NUMBER OF INTESTINAL RUPTURES | DURATION OF INJURY BEFORE OPERATION | REASON CASE WAS NOT OPERATED UPON | RESULT |
|---|-----|-----------------------------------|--------------------------------|-------------------|-----------------------------------|---|-------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|
| <i>Intestinal and Mesenteric Injuries Due to Automobile Accidents</i> | | | | | | | | | | |
| 1. M | 12 | Caught between automobile bumpers | - | × | - | - | - | 7½ hr. | - | Recovery |
| 2. M | 36 | Struck by auto-mobile | - | × | Rupture kidney and liver | - | - | - | Diagnostic error | Death, hemorrhage |
| 3. M | 45 | Struck by auto-mobile | Ileum | - | - | Retroperitoneal hemorrhage; fracture, pelvis | 1 | - | Moribund | Death, shock |
| 4. M | 28 | Steering wheel struck mid-abdomen | Ileum | × | - | Fracture, transverse process lumbar vertebrae | 1 | 15 hr. | - | Recovery |
| 5. M | 32 | Struck by auto-mobile | Bruise of bowel only | × | - | - | - | - | Moribund | Death, hemorrhage and peritonitis |
| 6. M | 63 | Struck by auto-mobile | - | × | - | Fracture, pelvis | - | - | Diagnostic error | Death, hemorrhage and shock |

not there is external evidence or history of trauma directly to the abdomen. Examination of the abdomen for tenderness, rigidity, and especially evidence of free fluid, should be painstaking. Prompt and adequate treatment of shock is essential, for these cases constitute desperate risks and a lethal outcome will result unless shock and hemorrhage are combated promptly to improve the patient's condition sufficiently to permit operation.

Of 18 cases of bowel rupture, the perforations were single except in 2 cases. There were 2 in this group that were not operated upon because the patients were in extremis.

DURATION OF INJURY BEFORE OPERATION

The importance of early diagnosis and prompt treatment is well illustrated in this group of cases. Ten patients operated upon within eight hours gave a mortality of 10 per cent. Six were operated upon after eight hours with a mortality of 66 per cent. Nine cases without operation died. According to Lockwood,⁹ the best results follow operation between two to four hours after injury, the mortality rate increasing approximately 15 per cent every four hours thereafter.

SIEGEL'S STATISTICS (SENN¹³)

| | | MORTALITY |
|----------------------------|---------------|-----------|
| Cases operated upon during | first 4 hours | 15.2% |
| Cases operated upon | 5 to 8 hours | 44.4% |
| Cases operated upon | 9 to 12 hours | 63.6% |
| Cases operated upon later | | 70.0% |

Massie,¹⁰ on the other hand, reporting 31 cases operated upon with a mortality of 78 per cent, did not believe the time factor to be of such great importance.

TREATMENT

Even though shock is not present at onset, it may occur during the operative procedure and this event should be anticipated. Restoration of the blood volume should be promptly instituted. In this series blood transfusions were used in 11 cases and 6 per cent gum acacia, an adequate emergency substitute, in a lesser number. The facility with which transfusions of blood are given in this institution obviates, to a large extent, the necessity for the use of acacia except in extreme cases. Hemorrhage is treated in conjunction with shock and by operation not too long delayed. Peritonitis, a complication of delayed treatment, can be prevented by early operation. Operation should be undertaken within a period of four or five hours after injury. This gives ample time to treat shock if such treatment is to avail and is early enough to avoid the onset of peritonitis. As far as the operative procedure is concerned, intestinal resections are to be avoided if simple closure of the perforation and repair of the mesentery will suffice.

TABLE I—CONT'D

| SEX | AGE | NATURE OF TRAUMATIZING FORCE | LOCATION OF INTESTINAL RUPTURE | FEAR OF MESENTERY | ASSOCIATED INTRAPERITONEAL INJURY | ASSOCIATED EXTRAPERITONEAL INJURY | NUMBER OF INTESTINAL RUPTURES | DURATION OF INJURY BEFORE OPERATION | REASON CASE WAS NOT OPERATED UPON | RESULT |
|---|-----|---|--------------------------------|-------------------|-----------------------------------|-----------------------------------|-------------------------------|-------------------------------------|-----------------------------------|--------------------|
| <i>Intestinal and Mesenteric Injuries Due to Miscellaneous Causes</i> | | | | | | | | | | |
| 1. M | 5 | Pinned to wall by trailer tongue | Ileum | x | - | - | 1 | 6 hr. | - | Recovery |
| 2. M | 18 | Fall, abdomen striking plank edge | Ileum | - | - | - | 1 | 5½ hr. | - | Recovery |
| 3. M | 74 | Kicked in abdomen by horse | Ileum | - | - | - | 1 | 5½ hr. | - | Recovery |
| 4. M | 62 | Balo of hay struck hernia (truss) | Jejunum | - | - | - | 1 | 8 hr. | - | Death, peritonitis |
| 5. M | 37 | Fall into water, abdomen striking floating polo | Ileum | - | - | - | 2 | 25 hr. | - | Death, peritonitis |
| 6. M | 8 | Fall, striking abdomen on end of metal pipe | Ileum | - | - | - | 1 | 7½ hr. | - | Recovery |
| 7. M | 40 | Jumped from window | Descending colon | x | - | - | 1 | - | Moribund | Death, peritonitis |
| 8. M | 30 | Struck in abdomen by fist | Ileum | - | - | - | 1 | 10 hr. | - | Recovery |

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Intraperitoneal drainage should be the rule except in early cases. Four early cases in this series were closed without drainage and recovered. Limited areas of the bowel wall which are severely bruised or otherwise traumatized without actual perforation should be carefully repaired or covered with omentum to prevent the possible catastrophe of late or secondary perforation.

Enterostomy may be indicated, as Commseller⁶ advises in writing on gunshot wounds of the bowel, for the purpose of relieving tension on the suture line in all cases of multiple perforations. An enterostomy was performed in 1 case of perforated ileum of twenty-five hours' duration. Death occurred from generalized peritonitis.

The cases in this series that were operated upon early and recovered were remarkably free of postoperative complications.

SUMMARY AND CONCLUSIONS

1. The mechanism of intestinal and mesenteric injuries is described.
2. The importance of careful abdominal examination in traumatic injuries is stressed. Attention is called to the fact that usually little evidence of external injury to the abdominal wall will be found.
3. Symptoms and signs are described with special reference to abdominal pain, tenderness, rigidity, evidence of intraperitoneal fluid, vomiting, and the pulse and temperature.
4. Factors which influence the mortality rate are considered with reference to: (A) the nature of the traumatizing force, (B) location of the intestinal perforation, (C) mesenteric tears with special reference to the frequency and high mortality of those unassociated with bowel rupture, (D) associated injuries, and (E) duration of the injury before operation.
5. The treatment of shock is emphasized.
6. It is believed that the optimum time for operation is from two to five hours after injury.
7. Operation is indicated when a reasonable suspicion of intraperitoneal injury exists based upon the symptoms and signs enumerated whether or not there is evidence of external abdominal trauma or a history of direct abdominal violence.

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toxin, causing a severe anemia; and, finally, a pure systemic toxin. The last two may easily be the result of a single toxin.

The following clinicopathologic classification is suggested, dependent upon the relative degree of the various toxins present, the extent of the local pathology, and the relation of the lesion to the severity of the systemic toxemia:

1. *Primarily Toxic (Fulminating).*—Toxemia far out of proportion to local lesion.

2. *Primarily Gangrenous (Mechanical).*—Local lesion out of proportion to systemic toxemia.

3. *Usual or Common.*—Toxemia in proportion to local lesion.

4. *Localized or Delayed.*—Lesion and toxemia relatively mild.

The fulminating case is quite classical and usually offers no diagnostic difficulty. The patient is in a state of profound shock with a rapid, thready pulse, low blood pressure, a delirious state, and temperature which varies from 103 to 105°. The respirations are rapid and frequently labored and characteristically there is a marked anemia present. Following traumatic injuries, the recognition is immediate, but as a complication in the clean postoperative case the surgeon is frequently confused. In the latter instance an erroneous impression of occult bleeding is likely to be had.

The primarily gangrenous type due to mechanical occlusion of the main vessels is characterized by a mortified and gaseous extremity which is clinically obvious. In these cases the toxemia is relatively mild because of the lack of absorption due to venous compression.

The usual, or common, variety occurs in neglected open or partially open wounds of 24 or 48 hours' duration. The gas is not so destructive as it never develops much pressure, but escapes through the open wound. The exudate is likewise discharged rather than absorbed. The degree of toxicity is usually proportionate to the extent of the local lesion; however, this is not a strict rule.

The localized or delayed type occurs in old wounds. The lesion is well walled off and the offending agents are of low virulence. Such conditions are usually discovered by incision, culture, or x-ray.

Diagnosis in gas bacillus infection is relatively easy and the detection of early cases is not difficult if the disease is kept in mind. All potentially infected wounds should be scrupulously examined, not daily, but every four or five hours. The onset of gas infection can be detected before the systemic symptoms are manifested in all except the extremely fulminating cases. Pain of a severe degree and out of proportion to the size of the lesion is considered the earliest constant finding. One should not wait for the appearance of systemic manifestations, such as agonizing pain, rapid thready pulse, high temperature, restlessness, prostration, and apprehension. Exquisite pain on pressure, edema, and diffuse reddening about the wound are early findings. Slight pressure will

Editorial

Gas Bacillus Infection

GAS bacillus infection can be prevented; with the recent methods offered, not only will many lives be saved, but many limbs as well.

In gas bacillus infection the etiologic agent, the *Cl. welchii* group, and the predisposing factor, trauma, are absolutely interdependent. These anaerobes constitute a large group of bacilli, widely distributed in nature and composed of saprophytic and pathogenic organisms. *Cl. welchii* (Weleh and Nutall), *Vibrio septique* (Pasteur), and *Cl. oedematiens* (Weinberg and Séguin) are the more important pathogens commonly associated with this disease. In this country *Cl. welchii* is the most common causative agent.

Deep penetrating wounds with destruction of muscle and liberation of carbohydrates form ideal growth conditions for these organisms, and because of this, the incidence is highest in compound fractures. Next in order of frequency are the penetrating injuries to soft parts, especially those incurred by shotgun. Statistics obtained during the World War reveal that five times as many compound fractures are complicated with this infection as are injuries to the soft parts.

In civil practice, auto and train accidents, especially those occurring in rural sections, carry the greatest incidence of infection. Shotgun is another great instrument of trauma, the wounds of which are frequently complicated with anaerobic infections. Gage has cultured *Cl. welchii* from the wool wadding of shotgun shell in every attempt.

The lesion is primarily a local one, but systemic reactions occur rapidly, especially in the fulminating cases. When infection occurs, the muscle at first assumes a brick red color resembling cooked meat. It soon softens, becomes diffuent, and changes in color to a green, brown, or black. Gas is formed and forces itself up and down the muscle bundles, opening up new fields for infection. The gas, according to Thorek, is the result of fermentation of isomaltose and dextrose converted from the glycogen of the living muscle. Taylor and Manson have demonstrated that this gas may develop high pressure. In two hours the pressure rises and in six hours a pressure of 23 pounds has been obtained. Thus more muscle is destroyed by impairing its blood supply, either by air emboli or pressure. Even the main trunk may be occluded, especially if the wound is closed or enclosed in a rigid cast.

Powerful exotoxins are produced and clinically there are three toxins: a local necrotizing toxin, producing necrosis of muscles; a hemolytic

a recent valuable development. We have treated eight definitely contaminated wounds with no occurrence of the disease, but such a series is of no significance.

The treatment of a developed case requires prompt and adequate surgical methods. The progress of the infection must be stopped and the symptoms must be relieved. These patients are invariably poor operative risks, and the severity of the toxemia should determine the degree of radicalism. The radical methods used so frequently in the past have claimed many lives unnecessarily. With the institution of "less radical" methods, antitoxin, and the x-ray, most of these patients could have been saved. Conservatism plays no part in the treatment of this disease. The methods advocated are decompression and débridement. Adequate decompression will prevent the progress of the destructive gas. Débridement means the excision of local lesion, especially the necrotic muscle. Surgery must be more extensive than the lesion, and muscle should be excised until there is a good blood supply and contractility is present. The wound is left wide open and irrigated with hydrogen peroxide. The latter is superior to all other fluids in the treatment of gas bacillus infection because of the liberation of nascent oxygen.

In cases of mechanical obstruction in which there is little toxemia, amputation can be accomplished quite safely following the usual pre-operative supportive measures.

The use of serum therapeutically is still under discussion, but most of the reports indicate its value. There are two plausible explanations for its inefficiency in certain cases; either the serum was given late, and not in adequate doses, or the serum was monovalent or bivalent and not polyvalent, which is essential.

Roentgen irradiation therapy is a valuable adjunct in the treatment of gas bacillus infections. The factors upon which the beneficial effects of the x-ray are dependent are not known, and although many hypothetical explanations have been offered, none have been proved.

Less radical methods, combined with adequate dosage of polyvalent antitoxin and the therapeutic x-ray, will cure the usual case with little sacrifice of tissue. Furthermore, in the extremely toxic cases, where amputation although indicated is incompatible with life, the application of these methods will control the infection, combat the toxemia, and thus improve the general condition so that the necessary surgery can be done safely later.

A critic may think that those interested in this work are too enthusiastic over a mortality rate based on so few cases. But when one witnesses the spectacular effect of the therapeutic x-ray in gas bacillus infection he will realize that its value is not overestimated, and that the method is well worthy of further study.

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express a thin watery or sanguinous fluid with or without a few bubbles of gas. A direct smear will reveal gram-positive, encapsulated, non-motile bacilli with staphylococci and streptococci, which is diagnostic.

In the past such diagnostic criteria may have seemed inconclusive for the institution of therapy, especially when amputation was resorted to immediately. But in this day of less radical methods, such findings are absolutely adequate. If a diagnosis is not confirmed by culture no harm has been done. The lesion was correctly treated as an infected wound with the addition of other more specific measures.

The use of x-ray in the diagnosis has received too little attention. In deep-seated wounds, careful successive examinations have proved it of value.

Gas bacillus infection has always carried a greater mortality rate than practically any other infection. The American Expeditionary Forces in France had a mortality of 48.5 per cent from this infection. In the postwar period two definite reductions were obtained. Immediately following the World War, the primary reduction was undoubtedly dependent upon the improvement of surgical methods. The second reduction occurred with the universal use of polyvalent antitoxin. Recently, with the valuable work of Kelly and others on the therapeutic use of x-ray, an even greater reduction in death rate is obtained. In his group of collective cases the mortality rate ranged from 5 to 10 per cent, depending on the type of case. The author, in collaboration with R. W. Cooper, reported twenty cases treated in a similar manner with mortality of 10 per cent.

The primary aim in treatment is to prevent the development of the disease. In no other phase of surgery is prophylaxis more important than in treatment of traumatic injuries. The immediate and proper care of wounds in general is the chief factor in reducing the incidence of gas bacillus infection. Under general anesthesia the field should be carefully prepared and a complete débridement performed. Muscle should be excised until it bleeds freely and contracts. If the surgeon is positive that the débridement is complete, he may close the wound tightly. If there is any doubt, the wound should be left open. A drain should never be used as it permits an entrance for organisms into the wound, as well as an exit for the collected secretions. In compound fractures the wound is treated in a similar manner, but in addition small fragments of bone are removed and contaminated edges of the larger fragments are excised with rongeurs. Interlocking of fragments with slight manipulation is often possible, especially in oblique fractures. In most compound fractures it is wiser to leave the wound wide open.

Prophylactic antitoxin given early, and in adequate dosage, is a definite preventative measure. The use of the x-ray prophylactically is

level. The only ways of determining excessive salt intake are by weighing the patient daily and by determining the urinary excretion of salt, and at times even this latter index may fail.

In 1923, Haden and Orr⁶¹ recommended the administration of 1 gm. of sodium chloride per kilogram of body weight as the initial dose of salt in the treatment of the toxemia of intestinal obstruction. At the time they failed to realize that the salt administered was used to replace the salt lost by vomiting, believing that the function of the sodium chloride was to neutralize a toxin in the body. Nevertheless theirs was the first attempt to place salt administration on a quantitative basis. More recently Orr¹¹¹ has recommended 250 to 500 c.c. of a 2.5 or 5 per cent solution of sodium chloride intravenously for patients with marked hypochloremia.

In 1937, Faleoner and Lyall¹² made a definite advance toward placing sodium chloride administration on an accurate basis. They gave known amounts of salt to patients with hypochloremia and determined the resulting rise in the plasma chloride level. As a result of their studies, they concluded that "in hypochloreaemia about 20 grammes (from 15 to 30 grammes) of salt are required on the average to raise the plasma chloride by 100 mg. per 100 ccm."

Early in our investigation^{110, 112} of the salt requirements of surgical patients, two simple but fundamental principles became apparent. First, it seemed obvious that the salt needs of a child weighing 20 kg. must be quite different from those of an adult weighing three times that amount. Secondly, we reasoned that if one could determine what portion or per cent of the total body salt had been lost to produce a given degree of hypochloremia one could calculate accurately the amount of salt that must be given to restore the body chlorides to normal.

The total salt content of the body has been discussed earlier in this paper. It will be recalled that Sherman¹¹ estimates the chlorine content of the body to be 0.15 per cent of the body weight, or expressed in terms of sodium chloride, 0.248 per cent of the body weight. On this basis, there are 148.8 gm. of salt in a 60 kg. individual; whereas, in a 20 kg. child there are only 49.6 gm. of salt. Thus, it is apparent that variations in body weight must be taken into consideration in determining the salt requirement of patients with hypochloremia.

It has also been shown that as secretions containing chlorides are lost from the body there occurs an accompanying fall in the plasma chlorides. Several workers have shown that this decrease in the plasma chlorides is also associated with a fall in the salt content of the other body fluids and tissues. It is a well-established fact that the concentration of chlorides in the cerebrospinal fluid parallels that in the blood

Advances in Surgery

BY ALFRED BLALOCK, M.D.

IN SURGICAL PATIENTS

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(Continued from the September issue.)

Treatment of Hypochloremia.—Hypochloremia may be prevented if the patient is under the observation of the physician at the onset of the loss of body salt. However, not infrequently the patient has lost an unknown amount of salt-containing fluids before he consults a physician, and in such instances the volume-for-volume rule cannot be applied.

There are several ways of approaching the problem of salt replacement in patients with hypochloremia. The method most commonly used in the past has been largely one of trial and error. That is, after the plasma chloride concentration has been determined, the clinician gives the amount of salt he thinks will probably be needed, and then again determines the plasma chloride level to see how accurately he has estimated the patient's requirements. This method has three faults. (1) If the plasma chloride concentration is checked too soon after the saline administration, a misleading value will be obtained. In the studies that we are about to report, an interval of at least 12 hours elapsed between the completion of saline administration and the plasma chloride determination in order to avoid any error in this regard. (2) If the salt need of the patient has been underestimated, valuable time will be lost in restoring the body chemistry and physiology to normal. (3) If an excessive amount of salt has been given to a sick patient, he is apt to retain the extra salt together with water and thus develop waterlogging of his tissues. Excessive salt administration usually will not be shown by an abnormally high plasma chloride level, since, as has been already pointed out, the plasma chloride concentration can rarely be forced above normal by large doses of sodium chloride. Often in sick patients it cannot be raised even to the lower limits of normal. Hence, if the clinician uses only the plasma chloride level as an index of overdosage of salt, he is apt to be misled into forcing salt upon the patient who is not able at the time to attain a normal plasma chloride

Experimental Observations.—In order to determine the practical value of these theoretical calculations, the formula was applied in the treatment of a series of cases with hypochloremia. Seven of the cases were the experimental subjects shown in Table VI in whom hypochloremia has been produced intentionally. These subjects were given salt in an amount approximately equal to that calculated to be necessary to restore the plasma chlorides to 560 mg. per cent. With one exception (G. W.), the salt was given intravenously in the form of physiologic saline or Ringer's solution at the rate of about 500 c.c. per hour. All of the urine was collected during the period of study and the salt excreted in this manner was determined. No other significant salt losses occurred.

The results of this study are shown in Table X. The close correlation between the amount of salt lost resulting in hypochloremia, the amount actually retained after salt replacement, and the calculated optimal retention based on the formula indicate that the theoretical principles of salt replacement that have been presented are sound. In two instances there is a noticeable discrepancy between the actual salt lost and the optimal retention calculated on the basis of the depleted plasma chloride level. In the case of G. W. the calculated optimal salt retention was considerably in excess of the actual salt lost. In this patient the unusually low plasma chloride concentration of 308 mg. per cent was produced in part by the forced ingestion of 3,400 c.c. of water by mouth in a short period of time. This resulted in the dilution of the chlorides remaining in the body. The use of this diluted plasma chloride concentration for the determination of the optimal salt retention resulted in a calculated salt need considerably in excess of the amount of salt which had actually been lost. In the case of H. A. about 16 gm. more salt were lost than were calculated to be necessary to restore the chlorides to normal. This discrepancy for the most part is accounted for by the unusually large excretion of salt in the urine (13.8 gm.) in the first two days on the salt-poor diet during which time no alteration occurred in the plasma chloride concentration.

The case of G. W. deserves additional comment for it illustrates a complicating factor in accurate salt administration. This patient was given 34 gm. of his total salt intake by gastric tube in the form of a 1.7 per cent solution. Soon afterward he passed two large watery incontinent stools estimated to be about 1,000 c.c. each. As pointed out by a number of workers, hypertonic salt solution stimulates peristalsis,¹¹²⁻¹¹⁵ and thus its use may result in inaccrancies by provoking abnormal losses through diarrhea.

Eleven other patients shown in Table XI had low plasma chlorides when first they came to our attention. This group included instances of pyloric and intestinal obstruction, rectal polyp with profuse rectal discharge, paralytic ileus, and patients who had been on gastroduodenal

serum.⁹ Hayden and Orr,^{74, 81} and Gatch, Trusler, and Ayers²⁸ showed that the decline in plasma chlorides was accompanied by a fall in the chloride concentration of liver and muscle tissues. The thorough work of White and Bridge¹¹ on dogs with experimental intestinal obstruction led them to the conclusions that chlorine is lost from the tissues in amounts directly proportional to the decrease in the chlorine content in the blood, and the total dechlorination of the body corresponds closely to the salt recovered in vomitus and urine.

All of these findings seem to warrant the assumption that the plasma chloride level is a satisfactory index of the chloride concentration throughout the body. Hence, if the plasma chlorides are 20 per cent below normal, it seems reasonable to assume that about 20 per cent of the body chlorides have been lost. On this basis, knowing the normal salt content of the body and the portion of it that has been lost as indicated by the plasma chloride level, one should be able to calculate the number of grams of salt that must be returned to the body to restore the body chlorides to normal. These concepts may be expressed in the form of simple equations as follows:

1. % of body salt lost =
$$\frac{\text{Normal pl. chl.} - \text{Actual pl. chl.}}{\text{Normal plasma chlorides}} \times 100$$
2. Total salt content of the body = 0.248 per cent of body weight (gm.)
From 1 and 2:
3. Number of gm. of salt needed to restore body chlorides to normal
= per cent of body salt lost \times total salt content of body
=
$$\frac{\text{Normal pl. chl.} - \text{Actual pl. chl.}}{\text{Normal plasma chlorides}} \times 100 \times 0.248\% \text{ of body weight (gm.)}$$

=
$$\frac{560* - \text{actual plasma chlorides}}{560} \times 0.00248 \times \text{body weight (gm.)}†$$

This formula becomes much simpler than it appears to be when applied to an actual case. For example, assume that one is dealing with a 60 kg. patient having plasma chlorides of 410 mg. per cent. The calculations under the conditions stated are as follows:

$$\text{Per cent of body salt lost} = \frac{560 - 410}{560} \times 100 = 26.8 \text{ per cent}$$

Total salt content of the body = 0.248 per cent \times 60,000 gm. = 148.8 gm.
Gm. of salt needed to restore body chlorides to normal = 26.8 per cent of 148.8 gm. = 39.9 gm. Thus, this individual would need 39.9 gm. of salt, which, if given in the form of physiologic saline solution (0.85 gm. per 100 c.c.), would amount to 4,694 c.c.

*The normal plasma chloride concentration varies from 560 to 630 mg. sodium chloride per 100 c.c. The lower limit was selected for the calculations because many sick patients will not attain a higher level. If it is desired, a higher value may be used in the formula.

†In some laboratories whole blood chlorides rather than plasma chlorides are determined. Using 450 mg. sodium chloride per 100 c.c. as the normal for whole blood, the formula calculation would be:

$$\text{Gm. salt needed} = \frac{450 - \text{actual blood chlorides}}{450} \times 0.00218 \times \text{body weight (gm.)}$$

Experimental Observations.—In order to determine the practical value of these theoretical calculations, the formula was applied in the treatment of a series of cases with hypochloremia. Seven of the cases were the experimental subjects shown in Table VI in whom hypochloremia has been produced intentionally. These subjects were given salt in an amount approximately equal to that calculated to be necessary to restore the plasma chlorides to 560 mg. per cent. With one exception (G. W.), the salt was given intravenously in the form of physiologic saline or Ringer's solution at the rate of about 500 c.c. per hour. All of the urine was collected during the period of study and the salt excreted in this manner was determined. No other significant salt losses occurred.

The results of this study are shown in Table X. The close correlation between the amount of salt lost resulting in hypochloremia, the amount actually retained after salt replacement, and the calculated optimal retention based on the formula indicate that the theoretical principles of salt replacement that have been presented are sound. In two instances there is a noticeable discrepancy between the actual salt lost and the optimal retention calculated on the basis of the depleted plasma chloride level. In the case of G. W. the calculated optimal salt retention was considerably in excess of the actual salt lost. In this patient the unusually low plasma chloride concentration of 308 mg. per cent was produced in part by the forced ingestion of 3,400 c.c. of water by mouth in a short period of time. This resulted in the dilution of the chlorides remaining in the body. The use of this diluted plasma chloride concentration for the determination of the optimal salt retention resulted in a calculated salt need considerably in excess of the amount of salt which had actually been lost. In the case of H. A. about 16 gm. more salt were lost than were calculated to be necessary to restore the chlorides to normal. This discrepancy for the most part is accounted for by the unusually large excretion of salt in the urine (13.8 gm.) in the first two days on the salt-poor diet during which time no alteration occurred in the plasma chloride concentration.

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Eleven other patients shown in Table XI had low plasma chlorides when first they came to our attention. This group included instances of pyloric and intestinal obstruction, rectal polyp with profuse rectal discharge, paralytic ileus, and patients who had been on gastroduodenal

TABLE X
REPLACEMENT OF BODY CHLORIDES IN EXPERIMENTAL SUBJECTS WITH HYPOCHLOREMIA
(FORMULA CALCULATION BASED ON NORMAL PLASMA CHLORIDE LEVEL OF 560 MG. NaCl /100 C.C.)^{*}

| SUBJECT | BODY WEIGHT KG. | NACL. LOST DURING URINARY AND FECAL PERIODS GM. | DEPLETED PLASMA CHLORIDES MG. % | PLASMA CO_2 COMBINING POWER VOL. % | NACL. GIVEN GM. | NACL. LOST | | | NACL. RETAINED GM. | OPTIONAL RETENTION FORMULA CALCULATION GM. | FINAL PLASMA CHLORIDES MG. % | FINAL PLASMA CO_2 COMBINING POWER VOL. % | CLINICAL REVL. GM. |
|---------|-----------------|---|------------------------------------|---|-----------------|------------|-----------|-----------|--------------------|--|---------------------------------|---|--------------------|
| | | | | | | URINE GM. | STOOL GM. | TOTAL GM. | | | | | |
| R. W. | 59.7 | 37.7 | 384 | 75.1 | 46.7 | 1.4 | 0 | 1.4 | 45.3 | 44.2 | 516 | 63.6 | 49.6 |
| S. T. | 73.2 | 35.2 | 436 | 67.3 | 42.8 | 0.5 | 0 | 0.5 | 42.3 | 40.1 | 554 | 56.3 | 45.4 |
| G. W. | 75.4 | 37.9 | 368 | 53.9 | 80.1 | 14.7 | 4 | — | — | 84.1 | 531 | 53.5 | 95.0 |
| H. A. | 76.9 | 52.3 | 454 | 49.5 | 38.2 | 0.7 | 0 | 0.7 | 37.5 | 36.1 | 545 | 60.7 | 40.8 |
| J. W. | 59.8 | 18.1 | 447 | 61.4 | 26.2 | 1.1 | 0 | 1.1 | 25.1 | 29.9 | 546 | 58.9 | 33.8 |
| T. J. | 72.7 | 36.3 | 427 | 59.9 | 40.6 | 0.0 | 0 | 0.0 | 40.6 | 42.7 | 564 | 48.0 | 48.3 |
| W. P. | 67.7 | 30.3 | 436 | 57.3 | 33.7 | 1.5 | 0 | 1.5 | 32.2 | 37.1 | 543 | 58.3 | 42.0 |

^{*}Note the close correlation between the sodium chloride lost during depletion, the sodium chloride retained in restoring the plasma chlorides to normal, and the optional retention. Note also the proximity of the final plasma chlorides to 560 mg. per cent.

TABLE XI
TREATMENT OF HYPOCHLOREMIA
FORMULA CALCULATION BASED ON NORMAL PLASMA CHLORIDE LEVEL OF 560 Mg. NaCl/100 C.C.)*

| PATIENT | WEIGHT KG. | INITIAL PLASMA CHLORIDES MG. % | INITIAL PLASMA CO ₂ -COMBINING POWER VOL. % | NaCl GIVEN GM. | URINE GM. | GASTROINTESTINAL FLACT GM. | STOOL GM. | TOTAL GM. | NaCl RETAINED GM. | OPTIMAL RETENTION POTASSIA CALCULATION GM. | FINAL PLASMA CHLORIDES MG. % | FINAL PLASMA CO ₂ COMBINING POWER VOL. % | CLINICAL RULE GM. |
|----------|------------|--------------------------------|--|----------------|-----------|----------------------------|-----------|-----------|-------------------|--|------------------------------|---|-------------------|
| G. M. | 62.5 | 404 | 27.9 | 54.8 | 7.7 | 3.2 | 0 | 15.0 | 40.8 | 43.7 | 559 | 52.0 | 49.6 |
| B. S. | 59.0 | 449 | 23.6 | 28.4 | 9.2 | 1.2 | 0 | 10.4 | 18.0 | 19.2 | 493 | 67.1 | 21.6 |
| J. C. | 65.5 | 479 | 45.7 | 27.5 | 2.6 | 1.4 | 0 | 4.0 | 23.5 | 23.4 | 586 | 44.7 | 26.5 |
| D. C. | 60.1 | 513 | 50.8 | 15.8 | 1.3 | 0 | 0 | 1.3 | 34.5 | 12.6 | 561 | 53.9 | 14.2 |
| D. E. | 58.1 | 345 | 100.0 | 103.6 | 9.2 | 38.1 | 0 | 44.3 | 56.3 | 55.3 | 606 | 73.0 | 62.5 |
| D. A. D. | 62.0 | 372 | 75.0 | 70.1 | 14.9 | 5.5 | 0 | 20.4 | 49.7 | 51.6 | 566 | 60.0 | 58.3 |
| C. K. | 48.0 | 356 | 48.0 | 56.8 | 0.7 | 1.1 | 17.9 | 19.7 | 37.1 | 44.1 | 528 | 49.8 | 49.8 |
| S. L. | 21.8 | 479 | — | 8.7 | 0.9 | 0 | 0.8 | 1.7 | 7.0 | 7.8 | 536 | — | 8.8 |
| L. H. D. | 54.0 | 461 | — | 25.7 | 4.4 | 0.3 | 0 | 5.7 | 20.0 | 22.9 | 554 | — | 25.9 |
| B. M. | 34.0 | 437 | — | 24.3 | 0.2 | 0 | 0 | 0.2 | 21.1 | 18.5 | 513 | — | 20.9 |
| G. H. | 45.3 | 552 | — | 61.5 | 10.9 | 4.8 | 0 | 15.7 | 45.8 | 43.7 | 510 | — | 47.1 |

*Note the close correlation between the sodium chloride retained and the optimal retention calculated on the basis of the formula. Also note the proximity of the final plasma chloride level to 560 mg. per cent.

suction without accurate replacement of the drainage losses with physiologic saline solution. These cases were treated in a manner similar to those already discussed, their chloride needs being calculated on the basis of their weight and their initial plasma chloride level. If the patient was losing chlorides through some abnormal source during the period of correction of the hypochloremia, these losses were replaced by the volume-for-volume rule. In a few cases small amounts of salt were given orally in addition to the intravenous administration. If the patient was dehydrated and the amount of fluid given as isotonic saline was not sufficient to correct the condition the extra water requirements were provided for by the intravenous administration of 5 per cent glucose in distilled water. In most of the patients a very satisfactory plasma chloride level was reached and there was a close correlation between the actual salt retained and the optimal retention as calculated by the formula.

Patient B. S. attained a plasma chloride concentration of only 493 mg. per cent. However, this seemed to be the maximum level for the patient at the time, for she excreted 9.2 gm. of salt in the urine and further administration of sodium chloride failed to raise the plasma chlorides significantly.

Patient C. K. was in a moribund state when she first came under our observation. She had a large rectal polyp associated with frequent watery stools and profuse rectal discharge. The salt content of this discharge was found to be 5.2 gm. per liter. Before half of the necessary salt had been administered, she was awake, and 24 hours after beginning the saline therapy she was sitting up in bed, mentally alert to the point of making witty remarks, and was taking food. One of the characteristic findings in these patients who are treated for hypochloremia is a definite euphoria as the plasma chlorides approach normal. The final plasma chloride level in this patient was only 528 mg. per cent but it will be noted that the actual salt retention fell 7 gm. short of the calculated need. This was due to the fact that the patient was losing more salt in the rectal discharge than we had anticipated, and so we had not made adequate allowance for this factor. The rectal polyp was removed and the patient left the hospital cured. If her moribund state had not been recognized as due to hypochloremia, she never would have come to operation.

The case of L. A. D. illustrates another instructive point. She was an 82-year-old female with a strangulated femoral hernia. Her calculated salt requirement was 51.6 gm. By mistake she was given 70.1 gm. Of the excess, 5.5 gm. were lost in gastroduodenal drainage and 14.9 gm. were promptly excreted in the urine, 49.7 gm. being retained. In general, we have found that small excesses of salt are readily eliminated by the kidneys, but, as has been pointed out previously, large excesses in sick patients tend to cause edema.

Patient G. B. is the case reported in detail in Table IV, illustrating the inability of some patients to attain a normal plasma chloride concentration.

In studying these patients we have found that some individuals will not attain the maximum plasma chloride concentration following the administration of a given amount of salt for a period of 36 hours. Falconer and Lyall¹² noted this same phenomenon and attributed it to chloride being stored in the tissues and later being used to raise the plasma chlorides. We have found that the individuals who are slow to reach a maximum plasma chloride concentration usually retain large amounts of water in the beginning, thus decreasing the salt concentration. As this excess water is excreted by the kidneys the plasma chloride level rises.

Clinical Rule.—As has been demonstrated, the formula for calculating the salt requirements of patients with hypochloremia is accurate, but for clinical purposes it is somewhat cumbersome, and a simpler rule was thought to be desirable. Accordingly, the following clinical rule based on the formula has been found to be very useful: *For each 100 mg. that the plasma chloride level needs to be raised to reach the normal, the patient should be given 0.5 gm. of salt per kilogram of body weight.* For example, if a 60 kg. individual has a plasma chloride level of 410 mg. per cent, the plasma chlorides need to be raised 150 mg. to reach the normal of 560 mg. per cent. The number of grams of sodium chloride required to accomplish this rise would be:

$$\frac{150 \text{ mg.}}{100 \text{ mg.}} \times 0.5 \text{ gm./kg.} \times 60 \text{ kg.} = 45.0 \text{ gm.}^*$$

It will be noted that this is only 5.1 gm. more than the figure obtained by the formula calculation for the same circumstances presented in an earlier paragraph. Because a patient receiving salt usually excretes a small amount in the urine, this slight excess is a desirable feature. The figures in the last column in Tables X and XI calculated on the basis of this clinical rule show a close correlation with the figures based on the formula calculation.

Complicating Factors.—Thus far the simple aspects of salt loss and replacement have been presented. There are, however, certain factors complicating the problem that are worthy of discussion. The chief of these is dehydration which almost invariably accompanies the abnormal loss of chlorides in clinical situations. Coller and Maddock¹³ have dem-

*For those who are accustomed to expressing body weight in terms of pounds rather than kilograms, the following rule has been formulated: For each 100 mg. that the plasma chloride level needs to be raised, the patient should be given 0.2 gm. of sodium chloride per pound of body weight. This amounts to 39.6 gm. of salt for the example cited.

A clinical rule based on whole blood chlorides rather than plasma chlorides is as follows: For each 100 mg. that the whole blood chlorides need to be raised to reach the normal of 10 to 12 mg. per cent, the patient should be given 0.6 gm. of sodium chloride per kilogram or 0.25 gm. per pound of body weight.

onstrated that a patient showing definite signs of dehydration has lost fluids amounting to about 6 per cent of his body weight. Thus, if a patient's dehydrated weight is used in calculating his salt requirements, less salt will be given than if his hydrated weight is used. Because hydration is the normal state, we believe that the patient's hydrated weight should be used in the calculations.* Dehydration also tends to concentrate the blood, which in turn raises the plasma chloride level. If the salt needs are calculated on the basis of this plasma chloride level, the amount of salt given again will be less than if the blood were not concentrated. It is possible to correct for this factor in the formula, but the excess of salt provided by the clinical rule of 0.5 gm. of salt per kg. of body weight for each 100 mg. rise in the plasma chlorides is sufficient to counterbalance the deficiency that might result in the calculations due to this concentration factor.

It has been mentioned previously that when sodium is lost abnormally from the body, water is also eliminated up to a certain point in an effort to keep the concentration of sodium in the body fluids constant. If sodium is lost in the same or greater amounts than chlorine (as indicated by a normal or low carbon dioxide-combining power), the chloride concentration of the plasma might be normal although significant amounts of both sodium and chlorine have been lost. Under such circumstances the plasma chloride level would not be of help in calculating the salt needs of the body. Such a patient, however, would be dehydrated as a result of losing body fluids containing salt, and so the suggestion of Coller and Maddock¹¹⁹ of giving the patient fluids amounting to 6 per cent of his body weight in the form of physiologic saline solution should be followed.

Frequently the patient with a duodenal, biliary, or intestinal fistula or with a profusely draining wound presents a difficult problem in management. If all of the fistulous or wound drainage can be collected and accurately measured, the losses should be replaced by the volume-for-volume rule. Usually, however, the losses cannot be accurately measured. Two possible methods of management then remain. One is to determine the plasma chlorides at frequent intervals and give salt as indicated. This would insure keeping the body chlorides at a satisfactory concentration, but the laboratory work would prove time-consuming and expensive and it would not indicate whether or not too much salt was being given. The other method is to follow the daily salt content of the urine. As long as a patient excretes more than 1 gm. of salt per day in the urine, there is little danger of serious salt depletion. On the other hand, if large excesses of salt are given, this is usually shown by large amounts of salt in the urine. For these reasons, and

*If only the dehydrated weight is known, the hydrated weight can be calculated as follows:

Hydrated weight = Dehydrated weight \div 0.94

because determination of urinary chlorides is a simple procedure, this method seems to be the more practical of the two. As an added precaution the plasma chlorides should be checked every 7 to 10 days.

Still another difficult problem in management is illustrated by the case of F. F. (Table XII), a 21-year-old male, entering the hospital with nausea, vomiting, abdominal pain, and distention. The plasma chlorides were 462 mg. per cent. His calculated salt need was 25.5 gm. of sodium chloride. At operation a diffuse thickening and inflammation of the whole mesentery of the small intestine was found and about 1,400 c.c. of ascitic fluid were removed from the peritoneal cavity. During the first 24 hours, the patient was given 4,079 c.c. of physiologic saline solution containing 34.7 gm. of sodium chloride. During the same period, 14.6 gm. were lost in gastrointestinal drainage and ascitic fluid. The plasma chlorides rose only to 500 mg. per cent, but the patient gained 1.4 kg. in weight. During the next three days the gastrointestinal losses were replaced with equal volumes of physiologic saline solution and additional fluids were given in the form of 5 per cent glucose in distilled water. The plasma chlorides dropped progressively to 437 mg. per cent, and the ascites progressively became more marked. It was apparent that the patient was retaining water to develop ascites and in order to make the ascitic fluid isotonic, salt was being drawn from other parts of the body. When another large amount of salt was given, the plasma chlorides rose only to 515 mg. per cent and the ascites continued to increase. Throughout the entire period of study, the urinary output of salt remained less than 1 gm. per day. Porges¹²⁰ and Mach¹²¹ also have noted the association of hyponatremia with ascites. The ideal method of managing such a case is not known, but this case does call attention to the fact that if a patient is developing ascites or hydrothorax, or edema, he will lower the concentration of the plasma chlorides unless considerable amounts of salt are provided. On the other hand, the administration of large amounts of salt will tend to increase the fluid retention. It is our opinion at the present time that, if the salt concentration of the body is decreased by the formation of ascites or hydrothorax, additional salt should be given to restore the chloride concentration to normal.

DISCUSSION

The term hyponatremia has been used frequently in this paper. Literally this term means a decrease in the concentration of the chlorides in the blood. This does not give a true conception of the condition which exists in these patients, because it implies that chlorides have been lost only from the blood; whereas, actually there has been a proportional loss from the interstitial fluids as well. We have used the term hyponatremia to mean a decrease in the total body salt as manifested by a

TABLE XII
CASE OF F. F. ILLUSTRATING THE DIFFICULTY IN MAINTAINING SALT BALANCE IN A PATIENT DEVELOPING ASCITES

| CASE OF F. F. ILLUSTRATING THE DIFFICULTY IN MAINTAINING SALT BALANCE IN A PATIENT DEVELOPING ASCITES | | | | | | | | | | | | | | | | |
|---|-------|-------|--------|--|-------------------------------------|------------|-----------------------------------|--------------------|------------|--------------|-----------|----------------------------------|-------------------|-----------|------------------------|------|
| FLUID INTAKE | | | | FLUID OUTPUT | | | | NaCl LOSSES | | | | | | | | |
| | | | | TOTAL C.C. | TOTAL NaCl | URINE C.C. | UPPER GASTROINTESTINAL TRACT C.C. | ASCITIC FLUID C.C. | STOOL C.C. | TOTAL C.C. | URINE GM. | UPPER GASTROINTESTINAL TRACT GM. | ASCITIC FLUID GM. | STOOL GM. | TOTAL GM. | |
| | | | | INTRAVENOUS 5% GLUCOSE IN DISTILLED WATER C.C. | INTRAVENOUS PHYSIOLOGIC SALINE C.C. | | | | | | | | | | | |
| BODY WEIGHT KG. | | | | ORAL C.C. | | | | | | | | | | | | |
| 24 HOURS ENDING 1938 | | | | | | | | | | | | | | | PLASMA CHLORIDES MG. % | |
| 1-24 | 52.10 | 0 | 1,740 | 4,079 | 5,819 | 34.7 | 220 | 1,280 | 1,420* | 0 | 2,920 | 0.1 | 7.5 | 7.1* | 0 | 14.7 |
| 1-25 | 53.49 | 0 | 3,260 | 1,300 | 4,560 | 11.1 | 463 | 1,180 | 0 | 0 | 1,640 | 0.2 | 6.9 | 0 | 0 | 7.1 |
| 1-26 | 55.25 | 0 | 4,030 | 1,214 | 5,244 | 10.3 | 1,260 | 1,780 | 0 | 0 | 3,040 | 0.6 | 9.2 | 0 | 0 | 9.8 |
| 1-27 | 55.53 | 0 | 3,060 | 1,822 | 4,882 | 15.5 | 1,050 | 2,475 | 0 | 0 | 3,525 | 0.1 | 11.6 | 0 | 0 | 11.7 |
| 1-28 | 54.66 | 0 | 1,003 | 5,000 | 6,000 | 42.5 | 1,070 | 2,440 | 0 | 0 | 3,410 | 0.4 | 11.6 | 0 | 0 | 11.7 |
| 1-29 | 56.10 | 0 | 0 | 0 | 0 | 1.3 | 380 | 0 | 0 | Incontinence | 380 | 0.1 | 0 | 0 | 0 | 12.0 |
| 1-30 | 55.31 | 1,130 | 2,000 | 0 | 2,675 | 0.5 | 450 | 250 | 0 | 900 | 1,600 | 0.2 | 0.8 | 0 | 9 | 0.1 |
| 1-31 | 54.84 | 675 | 960 | 2,015 | 4,325 | 20.0 | 700 | 480 | 0 | 1,150 | 2,330 | 0.5 | 4.4 | 0 | 3.6 | 4.6 |
| 2-1 | 56.24 | 1,350 | 0 | 0 | 0 | | | | | | | | | | 4.6* | 9.6 |
| Totals | 521.0 | 3,155 | 16,050 | 15,430 | 34,635 | 135.9 | 5,590 | 9,785 | 1,420 | 2,050 | 18,845 | 2.3 | 52.0 | 7.1 | 8.2 | 69.6 |
| *Estimates. | | | | | | | | | | | | | | | | |

*Estimates.

decrease in the plasma chloride concentration. Perhaps a different term, such as "hypoehloration," would more adequately convey the correct impression.

In referring frequently to chloride depletion and replacement, we have not wished to imply that the chloride ion alone is the one fundamentally involved. Undoubtedly the sodium ion is as important as, if not more important than, the chloride ion, but its determination is too complicated at present to be of use clinically. A fairly accurate estimate of the degree of depletion of the body sodium can be arrived at by a determination of the plasma carbon dioxide combining power in conjunction with the plasma chloride determination. However, from a therapeutic standpoint, in most clinical situations encountered by the surgeon correction of the chloride depletion with sodium chloride will also correct the sodium deficiency. Only in acidosis is sodium needed in excess of chloride. Even under such circumstances it is our belief that hypochloremia should first be corrected by giving the required amount of sodium chloride together with sufficient water and glucose to correct dehydration and ketosis. If, after the completion of such therapy, acidosis still persists, an attempt to correct it may be made by giving sodium lactate or bicarbonate. As mentioned previously, Gamble¹⁰⁷ has pointed out that if water and sodium chloride are abundantly supplied normal kidneys can be depended upon to correct the acid base balance of the plasma by excreting the ion not needed by the body. It has also been shown, especially by Haden and Orr,⁶² that chlorides other than sodium chloride are unsatisfactory for the correction of hypochloremia.

Salt is always lost from the body together with water and to replace one without the other is physiologically unsound. It is apparent, therefore, that the salt needed for the restoration of body chlorides should be given in isotonic or hypotonic solution. Hypertonic solutions are faulty in that they further dehydrate the patient and, because of their stimulating action on the bowel, tend to produce inaccuracies in salt administration by causing losses in diarrheal stools. Furthermore, in reviewing Haden and Orr's experiments,⁷² it is noted that a number of dogs with hypochloremia died during the administration of hypertonic salt solution. One of us (D. L. C. B.) has observed death in two cases of intestinal obstruction shortly after the administration of hypertonic salt solution. We have found that patients with hypochloremia will retain the salt needed if it is given intravenously at the rate of 400 to 500 c.c. per hour in the form of physiologic saline or Ringer's solution. If the patient is markedly dehydrated, additional fluids in the form of 5 per cent glucose in distilled water should be given to provide for water losses through the skin, lungs, and kidneys. This fluid may be added to or given alternately with the saline solution. When the

chlorides are very low, the total amount of fluid given may appear to be unusually large, but this, nevertheless, is the amount needed to restore the normal water and salt balance of the body.

A discussion of hypochloremia in relation to such nonsurgical conditions as diabetic, acidosis, adrenal insufficiency, nephritis, and pneumonia has purposely been avoided because of the lengthiness of this paper and because these problems are usually not the immediate concern of the surgeon. However, the discussion of the subject of salt balance cannot be brought to a close without a few brief remarks concerning water intoxication.

Water intoxication, resulting from the excessive administration of water by mouth or rectum and characterized by headache, nausea, asthenia, muscular irritability, salivation, convulsions, and death, was first described in man in 1922 by Weir, Larson, and Rountree,¹²² who correctly attributed it to an upset in the salt-water balance. They found that the condition could be corrected by the administration of salt solution and could be prevented if 10 per cent salt solution was given immediately before the administration of the water. Helwig, Schutz, and Curry¹²³ produced water intoxication in rabbits by proctoclysis of tap water. They found a marked fall in the blood chlorides and in the chloride content of the brain, kidney, and muscle. Autopsy of a fatal case of water intoxication in a human being reported by them showed a uniformly swollen brain with a rather dry outer surface, but the cut surface showed a smooth homogeneous "wet" appearance. Microscopically, there was an apparent increase in vacuolization of the stroma. In a later article Helwig, Schutz, and Kuhn¹²⁴ reported the recovery of a patient with water intoxication following the administration of hypertonic salt solution.

Cutting, Lands, and Larson¹⁹ have showed that "the lethal value for infusions of 1 per cent solution of sodium chloride in cats is of the order of 500 c.c. per kilogram of body weight when the rate of injection is 5 c.c. per kilogram of body weight per minute. This would correspond in a man weighing 154 pounds (70 kg.) to 35 liters at a rate of 350 c.c. per minute." They found no evidence of cerebral edema in these animals receiving massive infusions of saline solution. The fatal case of water intoxication reported by Helwig and others¹²³ received only 9 L. of tap water by proctoclysis within a period of 30 hours. Thus, the administration of water must be quite different from saline solution in its physiologic effect on the organism.

Of fundamental importance in understanding the mechanism of water intoxication is the work of Darrow and Yannet¹²⁵ on the redistribution of water when electrolytes are lost without corresponding loss of water. They have pointed out that almost seven-tenths of the body is made up of water which moves between intracellular and extracellular spaces in such a manner as to maintain osmotic equilibrium between the fluid of

the cells and that of the extracellular spaces. Since about nine-tenths of the osmotic pressure of the body fluids is maintained by electrolytes, the distribution of body water is largely determined by the distribution of these electrolytes. The chief constituents within the cells are probably proteins, potassium, and phosphates. The chief constituents of the extracellular fluids are sodium and chloride. Osmotic equilibrium is maintained largely by a shift of water from one side of the cellular membrane to the other. If the amount of electrolyte in the extracellular fluid is decreased, water passes into the cells from the extracellular spaces in order to equalize the electrolyte concentration on both sides of the cell membrane. Thus, the cells swell due to their increased water content.

From this we see that if a large amount of water is given rapidly to an individual with a normal salt concentration in the extracellular spaces, this concentration will be somewhat decreased due to dilution; water will pass into the cells to establish osmotic equilibrium; and mild symptoms of water intoxication will result. However, if the patient has been depleted of electrolytes, the salt concentration in the extracellular spaces is already at a critically low level. If the concentration of the electrolytes is suddenly decreased further by the administration of large amounts of water, the cells will swell markedly and severe symptoms of water intoxication will result. Swelling of the cerebral tissues causes the convulsions which characterize the end stage of this condition. Thus, the grave danger of giving water to a patient with hyponatremia and therefore with depleted electrolytes is apparent.

The treatment of water intoxication consists in the prompt administration of sodium chloride, and in this instance hypertonic saline given intravenously is the solution of choice.

Many problems of salt balance in surgical patients are still unsolved. Further studies are in progress at the present time in an effort to clarify some of them.

SUMMARY AND CONCLUSIONS

The maintenance of a proper salt balance is an important clinical problem commonly encountered by the surgeon. Practical aspects of salt metabolism in surgical patients have been presented, it being emphasized that excessive salt administration is apt to lead to the development of edema; whereas, loss of salt by vomiting, gastroduodenal suction, duodenal, biliary, and intestinal fistulas, diarrhea, wound drainage, or profuse sweating will lead to serious disturbance of the body chemistry. Loss of body chlorides, characterized by hyponatremia, is manifested clinically chiefly by lassitude, weakness, drowsiness, coma, anorexia, nausea, low pulse pressure, and dehydration.

It has been found that hyponatremia can be prevented if all abnormal fluid losses from the body are replaced with equal volumes of physiologic

saline solution. It has also been found advantageous to give 1 L. of physiologic saline solution during the first 24 hours of abnormal fluid loss in addition to the volume-for-volume replacement. This rule has been found especially useful in the management of patients with indwelling gastroduodenal suction.

For the accurate replacement of salt in patients whose body chlorides have been depleted, a simple formula has been developed based upon body weight and plasma chloride concentration. From this formula a clinical rule has been derived for the management of patients with hypochloremia; namely: for each 100 mg. per cent that the plasma chlorides need to be raised to reach the normal, the patient should be given 0.5 gm. of salt per kilogram of body weight in the form of physiologic saline or Ringer's solution. This rule has been found to work well in practice.

A number of complicating factors have been presented, and the relationship of hypochloremia to water intoxication has been discussed.

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strated new instruments for diagnostic and therapeutic purposes. Pope's instrument permits routine proctosigmoidoscopy, fulguration, electrocoagulation, or spray medication under a closed system. The electrode or spray is attached to a sliding sleeve. A suction tube with a release valve actuated by air infiltration removes smoke, or regulates light constant pressure, thereby obtaining precision, rapidity, and ease of operation. M. S. Kleckner, Allentown, Pa., discussed the importance of low spinal anesthesia in proctologic operations, believing it a satisfactory anesthetic for either anal or colonic surgical procedures. He prefers spinocain and varies the dose from 40 to 200 mg., and, with the exception of postoperative headache in a small percentage, has experienced no complications. M. S. Woolf, San Francisco, Calif., discussed the curability of chronic ulcerative colitis, basing his remarks on an analysis of seventy records of cases from the University of California Hospital. Woolf feels that, in spite of the unsatisfactory results of medical treatment, including the high percentage of recurrence and the absence of a specific curative therapy, the results and dangers of surgery, especially ileostomy and colectomy, make operative procedures even less desirable and concludes that the treatment of chronic ulcerative colitis should be purely medical. N. D. Smith, Rochester, Minn., agreed that medical measures had been more satisfactory in his hands than surgical procedure with the exception of complete colectomy, and A. B. Wilcox, Santa Barbara, Calif., felt that some of the unfavorable results in surgery in this disease resulted from a tendency to subject only moribund cases to operative procedures. M. C. Pruitt, Atlanta, Ga., from a study of 206 answers to questionnaires sent to proctologists and general surgeons found a remarkable variation in methods of treatment used for various minor anal lesions. The majority made a distinction in the treatment of early fissures and subsequent ulcers. Eighty-three injected anesthetics for fissure and the majority favored excision when ulcer is present. About one-half favored two-stage operations for complex fistulas; local applications were favored for mild pruritis, but forty-four methods were suggested for severe pruritis. The fungi are not regarded as etiologic by most of those questioned. Electrical methods have apparently been largely discarded for the treatment of internal hemorrhoids; injection is favored for early hemorrhoids; excision and suture is the most popular operative procedure. There was an almost equal division concerning early or late removal of strangulated hemorrhoids. The majority of those who answered the questionnaire kept patients in the hospital for an average of six days after hemorrhoidectomy. A. W. M. Marino, Brooklyn, N. Y., and his associates A. M. Buda and I. Skir presented a comprehensive review of the problem of anal tuberculosis. They believe that approximately 5 per cent of all individuals with tuberculosis develop fistula and report that 11 per cent of 367 fistulas seen by them proved to be tuberculous. Guinea pig inoculation with sectioning of the animal's enlarged nodes is the ideal diagnostic method. While Marino originally used the cautery in fistulectomy, he now uses sharp dissection without untoward effects. A. J. Chisholm, Denver, Colo., stated that the majority of tuberculous fistulas occur in institutional patients where concentrated food and inactivity cause constipation, with resultant fissure or cryptitis. The anal abrasions are subsequently invaded by swallowed acid-fast organisms in the stool. Chisholm found tubercle bacilli in 77 per cent of cases with active phthisis and in 55 per cent of cases with arrested pulmonary lesions. They were not found in 106 cases free from pulmonary tuberculosis. His surgery is done with a modified Percy cautery, which he believes more effective and less dangerous than the scalpel. He has found that activity of the disease in the chest is no bar to surgical procedures.

The very extensive literature on various phases of anorectal and colonic disease, which appeared in 1937, was reviewed in detail by H. I. Silvers, Atlantic

Review of Recent Meetings

THE AMERICAN PROCTOLOGIC SOCIETY

CURTICE ROSSER, M.D., DALLAS, TEX.

(From the Section on Proctology, Baylor University Medical School)

THE thirty-ninth annual meeting of the American Proctologic Society was held June 11, 12, and 13, 1938, at the St. Francis Hotel in San Francisco, Calif. This group has a fellowship limited to seventy-five with one hundred associate members.

In his presidential address, H. Z. Hibshman, Philadelphia, Pa., stressed the present need for additional graduate teaching of proctology and the necessity for continued efforts to set up proper standards for the specialty with a mechanism for certification of proctologists. He further suggested the possible advisability of a national journal for the specialty.

The history of proctology and the management of prolapse of the rectum were featured on the scientific program. A. J. Zobel, San Francisco, Calif., related incidents in connection with the development of the Society during the past three decades; G. S. Hanes, Louisville, Ky., delivered the biennial Joseph Matthews Address, recapitulating the history of the specialty from the period of his former associate, the world's first proctologist, Dr. Matthews. As part of the same symposium, M. R. Hill, Los Angeles, Calif., presented excellent photographic reproductions demonstrating the development of the art of illustration in connection with rectal diseases. In the Symposium on Prolapse, R. C. Alley, Lexington, Ky., reported an application of the Reid compression ligature for use in correcting prolapse of colostomy stoma; M. L. Emerson, Oakland, Calif., criticized the use of the elastic ligature for extensive prolapse of the rectum because of unfavorable results in his hands due to part of the colon's being caught by the constricting ligature; A. J. Murrieta, Los Angeles, Calif., described a new technique for correcting rectal prolapse, which is in effect a modification of his own valvotomy operation as reported in the 1931 Transactions of the American Proctologic Society. This procedure is carried out under a low spinal anesthesia and consists in wide excision of several segments of the rectal mucosa at different levels in a horizontal direction. Dudley Smith, San Francisco, Calif., reported favorable results in prolapse in twelve cases treated by several massive injections of 1:1,500 hydrochloric acid under anesthesia; H. T. Hayes, Houston, Tex., advocated castor oil with 1 per cent phenol used in a similar manner and E. H. Terrell, Richmond, Va., suggested the submucosal injection of 3 per cent quinine urea hydrochloride for mild prolapse.

Rare tumor formations about the rectum and anus were reported by W. R. Rainey, St. Louis, Mo.; R. L. Murdoch, Oklahoma City, Okla.; S. B. Klotzner, New Haven, Conn.; and J. F. Saphir, New York, N. Y. F. B. Campbell, Kansas City, Mo., reported an interesting case of a patient with multiple foreign bodies, and W. P. Black, Charleston, W. Va., and C. E. Pope, Evanston, Ill., demon-

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REPORT OF THE SECTION ON GENERAL AND ABDOMINAL
SURGERY OF THE MEETING OF THE AMERICAN
MEDICAL ASSOCIATION, SAN FRANCISCO, CALIF.,
JUNE 13-17, 1938

LEON GOLDMAN, M.D., SAN FRANCISCO, CALIF.

(From the Department of Surgery, University of California Medical School)

WALTMAN WALTERS, Rochester, Minn.: Surgical Lesions of the Adrenal Gland.—The clinical aspects of seven cases of adrenal cortical tumor were presented. These patients had their tumors removed without a death, and the symptoms were alleviated in all.

Adrenal cortical adenomas must be differentiated from the basophilic adenoma of the pituitary gland and the arrhenoblastoma of the ovary. Some of the differential points were discussed by the speaker. Masculinization of the female, characterized by hirsutism, acne, obesity, hypertrophied clitoris, and change in voice rather uniformly appeared in the patients with adrenal cortical adenoma. In the surgery of adrenal cortical tumors the preoperative and postoperative care is particularly important, as these patients may die of adrenal cortical insufficiency, unless this hormone is supplied in large amounts. Sodium chloride and sodium citrate solutions should be administered both before and after operation. The paragangliogliomas are the common tumors of the adrenal medulla and are characterized by paroxysmal hypertension, in contradistinction to the sexual changes produced by the cortical tumors.

Dr. Walters has discontinued the use of perirenal injections of air as a roentgenologic diagnostic procedure, because the tumor is often so small that its outline is not perceptible and also because of the danger of fatal air embolism.

Howard C. Naffziger, San Francisco, Calif., stressed the importance of proper preoperative and postoperative management in these cases. He stated that in so-called "basophilism" of the pituitary gland there may be either hyperplasia or adenoma of the adrenal cortex. He was inclined to feel that there may be two distinct clinical pictures, either the adrenal genital syndrome with reversal of sex, associated with adrenal cortical tumors; or the Cushing syndrome, in which there may be altered cortical function as evidenced by overproduction of cortin.

Hans Lissner, San Francisco, Calif., stated that the differential diagnosis of the three foregoing conditions is often very difficult. The distinction between arrhenoblastoma and adrenal cortical tumor is difficult because these two conditions often cause identical changes. He felt that the hormone test might be of value in the recognition of adrenal hyperplasia, and, because of the great difficulty of diagnosis, advocated the use of air injection to obtain roentgenological evidence of tumor.

Virgil Harlan Moon, Philadelphia, Pa.: Early Recognition of Shock and Its Differentiation From Hemorrhage (paper read by J. P. Schaeffer, Philadelphia, Pa.).—The author stressed the point that shock should be recognized and treated during its earliest stages and that, after the blood pressure descends below the

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City, N. Y. **H. I. Kallet**, Detroit, Mich., opened the discussion on the subject of radiation in the treatment of pruritis ani; the conclusions of **W. W. Green**, Toledo, Ohio; **V. G. Jeurink**, Denver, Colo.; and **D. C. McKenney**, Buffalo, N. Y., were that this form of treatment is often helpful temporarily and occasionally effective permanently. It is important that the dosage be kept within non-injurious limits. **T. E. Smith**, Dallas, Tex., reported a specific diagnostic scratch test for chaneroidal ulceration and reviewed the results of the treatment of this lesion with progressively increased intravenous injections of 1 per cent mereurochrome as originally suggested by **Curtice Rosser**, Dallas, Tex. This specific therapy has been employed for ten years in the dispensaries of the Medical Department of Baylor University.

N. D. Smith, Rochester, Minn., reported a series of cases in which perianal pyoderma simulated extensive anal fistula. Where this condition becomes chronic, Smith believes a radical excision is necessary. **H. E. Bacon**, Philadelphia, Pa., reported a large group of multiple malignancies of the lower bowel, some of which were apparently primary and others due to contact. In the discussion of his paper, **T. E. Jones**, Cleveland, Ohio, stated that, while he himself had seen 6 instances (5 of them involved the sigmoid and rectum and the other the cecum and the rectum), the incidence is so low (about 1 in 250 cases) that he did not believe it justified insistence upon protracted x-ray examination in every case where a single malignancy is discovered. **Howard A. Brown**, San Francisco, Calif., discussed the relief of intractable pain due to inoperable rectal cancer. In the experience of **H. C. Naffziger**, San Francisco, Calif., and himself, intradural injections of alcohol have not proved satisfactory and sections of the sympathetic nerves alone have been even less helpful. They, therefore, advocated chordotomy. **Dudley Smith**, San Francisco, Calif., felt that alcohol injections had given relief to so many patients in his hands and those of others and that the procedure is so much less hazardous than chordotomy that he believed the therapy originally suggested by **Dogliotti** should be given further trial. **T. E. Jones**, Cleveland, Ohio, stated that, even in inoperable malignancy of the rectum, excision of the primary growth is often justifiable for the relief of pain and that liver metastasis is not a bar to this step.

At the conclusion of the 1938 session, an invitation from the British Sub-Section on Proctology to conduct a joint meeting of the two organizations in London in June, 1939, immediately following the regular annual meeting of the Society in this country, was accepted and **Dudley Smith**, San Francisco, Calif., was elected President of the organization for 1938 to 1939.

The complete transactions of this meeting are available in book form under the editorship of **H. E. Bacon**, Philadelphia, Pa.

Leon Parker, San Francisco, Calif., remarked that the steel alloy metals are not permanently tolerated and that vitallium should answer the purposes of the orthopedist.

Martin B. Tinker, Jr., Ithaca, N. Y.: **Fracture of the Neck of the Femur.**—The speaker reviewed statistics on methods of external fixation for fractures of the neck of the femur and emphasized the high mortality, high incidence of nonunion, deformity, ankylosis, muscular atrophy, and prolonged hospitalization. The advantages of internal fixation of the neck of the femur are that the method usually is not associated with shock; the patient is immediately relieved of pain and may be up sooner. In competent hands most of the disadvantages mentioned above can be avoided by the use of internal fixation. This fixation should be firm enough to insure union, with considerable freedom of bodily movement. It was his opinion that, by the use of three Moore nails, better holding could be secured than by the use of one Smith-Petersen nail.

Kellog Speed, Chicago, Ill., stated that with immediate reduction of the fracture there are relief from pain and restoration of the patient's confidence. Because, in many cases, there is a tendency for the nail to lose the position of the fracture, he does not permit weight-bearing for from sixteen to twenty-four weeks.

E. W. Cleary, San Francisco, Calif., demonstrated by the use of lantern slides a special table which he devised. This table has instruments attached to act as a guide for the insertion of the nail. He claimed that some of the dangers of internal fixation were obviated by the use of this particular equipment.

Walter G. Stern, Cleveland, Ohio, felt that the introduction of a nail is a major operation which carries an operative mortality of 26 per cent. He advocated a subtrochanteric osteotomy for ununited fractures in order to convert the shearing force to a compression force which would then permit union to take place.

George W. Swift, Seattle, Wash.: **Cerebrocranial Injuries: Detailed Study of 1,433 Cases.**—Dr. Swift made a study of 1,433 cases of cerebrocranial injuries, treated in approved hospitals in the state of Washington over a period of one year. By familiarizing the staffs of the different hospitals with a definite program of treatment for head injuries, he felt that the mortality had been lowered. He advocated treatment of early shock and observation of the patient for hemorrhage, and stressed the control of water balance by means of spinal puncture, which he considered a very important factor in lowering the mortality. The control of secondary shock was mentioned. Massive hemorrhage cannot be controlled, but meningeal hemorrhage can be. Seventy-five and seven-tenths per cent of the patients who left the hospital, did so in one week. There was a mortality of 15 per cent for the series.

Harry E. Mock, Chicago, Ill., used cases of proved fracture of the skull as a measuring rod for his series. There are about 500,000 head injuries in the United States yearly. He divided his cases into two groups: fractures of the skull and fractures of the skull with blood in the spinal fluid. In the large series studied, from 50 to 60 per cent of the patients in the latter group died within twenty-four hours. He did not advocate routine measures in all cases and emphasized the need of early neurosurgical consultations. He utilized dehydration treatment in a series of 275 cases, carrying out spinal puncture in 34 per cent of patients with proved

critical level of 80 mm., the patient's condition is serious. Blood volume and flow should be the chief criteria for shock rather than the presence of a lowered blood pressure. The author found by experimental and clinical observation that the hemoconcentration is proportional to the gravity of the condition and that this concentration occurs early, often before the blood pressure begins to drop. The hemoglobin and red blood cell count, especially the latter, are dependable guides to the concentration of the blood. A 20 per cent concentration of the blood may take place without other evidence of shock. When a 40 per cent concentration of the blood is reached, the patient's condition is grave.

In hemorrhage there is hemodilution rather than hemoconcentration and this dilution is proportionate to the amount of blood lost.

Hemoconcentration is the result of the shock mechanism and is the earliest clinical test we have to detect it. The author made a plea for serial red blood counts in cases in which shock might be suspected.

J. Eastman Sheehan, New York, N. Y.: **The Use of Free Full Thickness Skin Graft.**—In the author's hands free, full thickness skin grafts have been efficacious in more than 95 per cent of applications. The advantages of this method are that it produces no surface defects and there is no change in pigmentation. The patients must be in good general health. Important factors in the process of such a procedure are the preparation and state of the skin and grafted area, atraumatic technique, use of pressure dressings with immobilization, and the administration of vitamin B if necessary. If, following surgery, the temperature becomes elevated or there is a discharge or odor, the presence of infection must be assumed, and the use of certain remedial measures oftentimes insures the survival of the graft. A beautiful colored motion picture was shown depicting the method of transplanting the graft.

George W. Pierce, San Francisco, Calif., stressed the importance of hemostasis, inasmuch as hemorrhage into the graft might cause its loss. He also stated that pigmentation is likely to occur in 20 per cent of the cases and probably will be marked in from 8 to 10 per cent.

H. F. Kirkham, Houston, Tex., stated that full thickness grafts could not be transplanted to the face of a negro because of the marked increase in pigmentation.

Charles Scott Venable, San Antonio, Tex.: **Electrolysis: The Controlling Factors in the Use of Metals in Fractures.**—Dr. Venable presented evidence gained by clinical means and animal experimentation to show that metal used for internal fixations of fractures will corrode if electrolysis develops. He demonstrated that, the body fluids being the electrolyte, electrolytic action takes place between metals and bone, by the transposition of ions, in accordance with the law of the electromotive force of metal. Without electrolysis, there can be no corrosion of metal. An alloy of cobalt, chromium, and molybdenum called vitallium has been shown through all experiments to be noncorrosive and so electrically neutral that it causes no tissue or osseous change. In addition its tensile strength compares favorably to that of other metals used. Dr. Venable showed several lantern slides of roentgenograms of patients for whom screws, plates, and nails prepared of vitallium had been used without evidence of corrosion of the metal or resorption of bone around them. Osteogenesis is not interfered with. The author proposed vitallium as the ideal metal for internal fixation because of its lack of electrolytic properties and its potential strength.

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skull fractures and 90 per cent of those with blood in the spinal fluid. In his opinion subarachnoid hemorrhage is an indication for spinal puncture. In over 80 per cent of the cases spinal puncture was done within twenty-four hours, approximately 20 c.c. of fluid being removed, with a mortality of 17.7 per cent. He thought it would be necessary to do a cranial operation in from 8 to 10 per cent of fractures of the skull, either for a depressed simple or compound fracture, an extradural hemorrhage, or a subdural collection of blood or fluid. Associated injuries are important and should not be overlooked.

Arthur Carroll Scott, Temple, Tex.: **The Early Differential Diagnosis of Breast Tumors.**—Dr. Scott devised a new method of physical examination to detect early carcinoma of the breast by eliciting the so-called "cancer shadow." This test is made possible because of the early invasion of cancer along the interlobular fascia and Cooper's ligament which attaches to the skin so that it drags on the skin and subcutaneous tissues. By using tangential illumination with a spotlight, in a dark room, and by supporting the breast properly, a depression shadow over the cancer area is seen. In his experience this cancer shadow was found to be accurate in 94 per cent of the malignant cases, and in 88.9 per cent of the benign cases, with a total accuracy of 91.6 per cent. He felt that by the use of this test one would often be able to avoid biopsies which run a risk of spreading the cancer during the surgical removal of the breast.

Irving Abell, Louisville, Ky., stated that he felt the cancer shadow test to be tenable only when the cancer is superficial enough to involve this superficial layer of Cooper's fascia. If the cancer were deep in the breast, the test might be negative. He also said that every tumor of the breast should be removed, whether benign or malignant, and when doing a biopsy for carcinoma, the entire tumor should be removed as the biopsy specimen, rather than cutting into the cancer and excising a small piece of tumor tissue.

Hugh H. Trout, Roanoke, Va., gave the Chairman's Address in the form of a demonstration, by colored motion picture, of a radical mastectomy conforming to the method devised by Halsted. Dr. Trout emphasized the importance of using the electric knife for taking biopsies of the breast and of removing the entire tumor when so doing. He stressed the main features of the operation as removing a wide margin of skin, depending on skin graft in cases of large tumors, and complete removal of the pectoral muscles and axillary lymph nodes. Radiation therapy should not supplant surgery but should be used in addition to it. Dr. Trout advocated implants of radium, especially over the region of the internal mammary vessels, at the end of the operative procedure. In addition, preoperative and postoperative radiation should be used. He utilized silk technique throughout. In the cases in which there was a large single metastatic lymph node in the axilla, the prognosis was much better than if multiple smaller lymph nodes were involved.

Howard M. Clute, Boston, Mass.: **Gastroduodenostomy for Certain Duodenal Ulcers.**—The speaker thought that in certain cases of duodenal ulcer an anastomosis could be made between the stomach and the second portion of the duodenum, with alleviation of symptoms. This procedure is facilitated by complete mobilization of the second portion of the duodenum after incising the lateral parietal peritoneum along the duodenal margin. The great advantages of this operation are that it does not cause shock, it carries a lower mortality than gastric resection, and it is followed by a very small incidence of stomal ulcers, only three having been reported in over 400 cases collected from the literature. It is satisfactory for

use in the relief of pyloric stenosis, and, in the treatment of a bleeding duodenal ulcer, it may permit exposure and suture of the ulcer as well as obviating the sequela of a gastrojejunostomy. In the treatment of a bleeding gastrojejunal ulcer, gastroduodenostomy may be resorted to in those patients who are poor risks, after the gastrojejunal stoma has been taken down. If the patient is a good risk, a gastric resection should be done; otherwise it is best to take down the stoma and do a gastroduodenostomy. In cases of a high gastric ulcer it may be wiser merely to excise the ulcer and do a gastroduodenostomy rather than to attempt a high gastric resection which may be associated with a greater operative mortality. In the patients operated upon, however, there is a high gastric acidity following surgery, but the incidence of stomal ulcers is nevertheless very low, which obviates this complication of gastroenterostomy.

Robert S. Dinsmore, Cleveland, Ohio, thought this an excellent procedure, especially after taking down a gastrojejunocolic fistula. He prefers gastroduodenostomy to doing a resection of the stomach when so much surgery is necessary.

Harold Thompson, Los Angeles, Calif., noted experimentally that the more of the stomach one removed, the lower the subsequent gastric acidity became, and that the procedure described by Dr. Clute does not cause this change.

John Oscar Bower, Philadelphia, Pa.: **Routine Operations Versus Scientific Management of Spreading Peritonitis Complicating Acute Perforated Appendicitis.**—Dr. Bower emphasized the fact that recovery from acute infections of the peritoneal cavity depends on the development of immunity in general and local tissues, much as in the recovery from any other acute infection. Seventy-one per cent of the patients who recovered from spreading peritonitis showed an antitoxin for *Clostridium welchii* toxin in the blood serum. Patients do not die of appendicitis or of local peritonitis, but rather of spreading peritonitis. In the group of patients reported, the mortality of spreading peritonitis was 26.9 per cent, but it rose to 37.4 per cent in the patients who were operated upon. Dr. Bower showed definitely that there is a higher mortality if the patient is operated upon during the fifth or sixth day of the disease than at any other stage of the inflammatory process. In the attempts of localization of peritonitis about a perforated appendix, he stressed the importance of the peripheral zone of inflammation about the central point, where attempts are made to create a barrier. Operation frequently breaks down this barrier, allowing the spread of peritonitis. Ten per cent of the deaths that occur in spreading peritonitis follow the drainage of appendiceal abscess; consequently the speaker made a plea for extraperitoneal drainage in these cases, even though a second incision may be required to enter the abscess directly. Thirty-three per cent of the patients showed an antitoxic titer to the Welch bacillus in the peritoneal exudate. Dr. Bower advocated the Ochsnerization of spreading peritonitis until localization had taken place, and the use of perfringens bacillus antitoxin. Patients get their first dose of antigen during the attack of appendicitis, the second when the appendix ruptures; then, after localization takes place, if operation on the patient with ruptured appendicitis is routine, the surgeon often gives the patient the third (so often the fatal) dose of antigen by breaking down the barrier. Among 365 surgeons who operated on 18,000 patients, the incidence of spreading peritonitis was 27 per cent. Dr. Bower emphasized the fact that children as adults do. He advocated the use of drains for perforated appendicitis of all types and advised that the drains be left in place for seven days.

Charles G. Johnson, Detroit, Mich.: *The Use of Small Intestine Decompression and the Treatment of Intestinal Obstruction.*—The author has utilized the method of intubation of the small bowel up to the point of the obstruction with continuous suction in order to remove the fluid, as in an enterostomy, thereby overcoming abdominal distention. Obstructions caused by strangulation are not to be included in this type of treatment. The tube, which is passed through the nose, consists of a No. 18 soft rubber nasal tube, about ten feet long, to which is attached a tube of small caliber, with an inflatable balloon at the end. The balloon is inflated after the tube is in the duodenum and from that point the tube is carried down to the point of the obstruction by peristalsis. This method is used to facilitate operative procedures in the treatment of simple intestinal obstruction and is not a substitute for surgery. It has the advantage that it tides the patient over the danger period so that an operation can be carried out, it completely controls the distention, and it may aid in localizing the obstruction by passing the tube down to the point of obstruction and allowing a small amount of barium to go through. In obstruction low in the small bowel the patient's nutrition may improve by having the tube at the site of obstruction and allowing the absorption of food, preferably taken by mouth; fluids also may be given through the tube if desired. It is an excellent method for the treatment of paralytic ileus. Suction from a tube in the stomach or duodenum will remove only that fluid and gas brought to the level of the tube, and only secondarily releases the tension of the dilated loops just proximal to the obstruction; this tube, however, has the effect of an enterostomy without the operative dangers. The method is excellent for preparing the patient for operation, in that it overcomes the dangers which normally are present in the handling of dilated bowel.

Frederick Collier, Ann Arbor, Mich., stated that decompression, as advocated by Wangensteen, was the greatest contribution to abdominal surgery during the last decade. The associated abnormal chemistry is important and may cause death if a marked hypochloremia is present. If the patient's blood chemistry is normal at the start, the administration of normal saline solution will replace the loss of fluid, volume for volume. In case the blood chloride is lowered, allowing 0.5 gm. of salt for each 100 mg. that the blood chloride is lowered, and multiplying by the patient's weight in kilograms, will give an idea of how much chlorides should be administered.

Fred W. Rankin, Lexington, Ky.: *One Stage Combined Abdominoperineal Resection of the Rectum for Cancer.*—Dr. Rankin reported seventy-five cases of abdominoperineal one-stage resection of the rectum with a mortality of 6.6 per cent and an operability of 76 per cent. He stressed the importance of fitting the procedure to the patient and not the patient to the procedure. The spread of rectal cancer along the superior hemorrhoidal vessels into the mesentery of the sigmoid, and less frequently laterally, demands wide removal of bowel and contiguous tissue. This type of operation can be satisfactorily carried out only by sacrificing the sphincter mechanism and accepting a colostomy. The Miles operation is the only one which permits complete removal of the zone of spread of the cancer. In specimens removed by this procedure, the incidence of metastatic carcinoma found in the lymph nodes removed with the specimens varied from 50 to 70 per cent of the cases. Patients with cancer of the rectum require a long period of preoperative care so that the general condition may be built up and the bowel thoroughly cleansed. Occasionally, because of the patient's condition or other factors, a Lockhart-Mummery type of operation is done. Dr. Rankin emphasized that the colostomy loop should be rather taut and without slack, to prevent prolapse later. He also stressed peritonization of the operative area to prevent subsequent obstruction. He showed lantern slides demonstrating the technique of the operation.

Thomas M. Joyce, Portland, Ore., stressed the importance of suturing the mesentery of the sigmoid colon to the lateral parietal peritoneum to prevent a loop of small bowel slipping through and causing obstruction, when the colostomy loop is brought out through a stab wound. He also emphasized the importance of making a large enough stab wound when bringing the colostomy loop out. In his experience the operability rate at a charity hospital was only 23 per cent, while that at a private hospital was 60 per cent.

Albert O. Singleton, Galveston, Tex.: **The Problem of Disruption of Abdominal Wounds and Postoperative Hernia.**—The commonly accepted causes of disruptions of abdominal wounds are infection; hematomas; delayed wound healing; undue strain by vomiting, coughing, or distention; faulty suture material, allergic reaction; and hypoproteinemia. The author added nonanatomic incisions as an important cause. The muscles in the upper abdomen are respiratory muscles and therefore an incision so placed undergoes more strain than one in the lower abdomen. The author made a plea for not incising muscle fibers transversely. In the usual rectus and midline incisions the transversalis muscle and posterior rectus sheath are usually incised longitudinally, thereby cutting through their fibers, which is non-anatomic. The author suggested the use of the Sloan incision. This is made longitudinally through the skin and the anterior rectus sheath but the recti muscles are retracted so as to allow the transversalis muscles and posterior sheath to be opened transversely in order not to sever their fibers. The lateral transverse incision is a paracostal one, made in the line of the muscle fibers, and is utilized for cholecystectomy when placed on the right side, or splenectomy on the left. It is made in the same manner as a McBurney incision by splitting each layer parallel with the course of its fibers. In a controlled series of cases the author noted an incidence of disruption in 1.02 per cent and hernia in 2.24 per cent of the so-called non-anatomic incisions, such as rectus or midline. With the use of the anatomic incision, the incidence of disruption was only 0.0031 per cent and of hernia 0.92 per cent. Other types of well-known anatomic incisions are the Pfannenstiel and the McBurney. The author feels that if incisions are made anatomically without severing muscle fibers, the incidence of hernia and disruption can be reduced.

R. L. Sanders, Memphis, Tenn., stated that the mortality of wound disruptions is from 25 to 40 per cent and that, in 500 of his own cases of cholecystectomy, the incidence of postoperative hernia was 8 per cent. He attempted, therefore, to use a more anatomic incision than he had used previously. He now utilizes a transverse incision across the epigastrium, going through the anterior rectus sheaths transversely, dissecting these sheaths upward off the underlying recti muscles, then retracting the recti muscles laterally and opening the transversalis muscle and peritoneum transversely, thereby not severing any muscle fibers. He made the point that because disruption never occurs after a McBurney incision, he utilizes the McBurney principle in the upper abdomen. Preservation of motor nerves is also an important factor.

Alton Ochsner, New Orleans, La., stated that the lateral transverse incision might be utilized, although he has had no experience with it. He remarked that in delayed healing he considers it of great importance to use silk sutures even though working on an infected case. If infection is anticipated, it is more urgent to use silk sutures rather than catgut in order to maintain the strength of the wound. He recommended that the silk be fine and interrupted and stated that many times infection would be avoided in an otherwise potentially infected wound.

Hugh H. Trout, Rounoke, Va., stated that there is a wide variation in the strength of eatgut which varies with the age of the animal from which it was prepared. He urged the proper preparation of debilitated patients for surgery as a precaution against disruption of wounds and postoperative hernia.

Frank G. Boland, Atlanta, Ga., is opposed to through-and-through sutures of the abdominal wall because of the danger of trauma to the bowel and peritonitis. He stressed the importance of firm closure as well as the necessity for exact closure of the peritoneum and the transversalis muscle.

Charles E. Phillips, Los Angeles, Calif.: **Mediastinal Infections Due to Esophageal Perforations.**—Dr. Phillips stated that it is the conception of medical authorities that acute suppurative mediastinitis is always fatal, particularly if it is due to a perforation of the esophagus. The esophagus is a very frail structure and injury by esophagoscopy or foreign bodies is not infrequent. Perforation usually occurs in the upper part of the esophagus due to contraction of the pharyngeal muscles. Because of the loose areolar tissue about the esophagus, rapid dissemination of infection takes place after perforation. The speaker presented a series of 26 cases of acute suppurative mediastinitis, 23 of which were due to esophageal perforations. Twenty-one operations were performed, with 4 deaths. Of the 5 patients not operated upon, 4 died. The diagnosis can be made by the history of the patient's having swallowed a foreign body or of having had an esophagoscopy followed by pain, subcutaneous emphysema, x-ray evidence of a foreign body or of emphysema, and by direct examination of the esophagus by esophagoscopy. The speaker recommended immediate surgical treatment by making an incision along the medial aspect of the sternocleidomastoid muscle, dissecting into the superior mediastinum and inserting several Dakin's tubes. If the posterior mediastinum is involved, it is necessary to remove segments of the upper ribs posteriorly. The patient is then fed through a nasal tube and Dakin's solution is used in the wound. He showed many clinical cases, roentgenograms, and slides of the wound demonstrated by lipiodol injections. He made a plea for early operation in mediastinitis and said that the condition is curable.

Simon Jesberg, Los Angeles, Calif., stated that very few foreign bodies rupture through the esophagus spontaneously, but that a perforation usually follows instrumentation. He condemned blind instrumentation of the esophagus and urged early drainage of the mediastinum, if possible, as soon as the diagnosis is made and before sepsis is present.

Claude Frank Dixon, Rochester, Minn.: **Management of Intestinal Fistulas.**—Dr. Dixon reported ninety cases of intestinal fistula and felt that the incidence had increased in the last few years due to cases of regional ileitis, appendicitis, and other causes. Intestinal fistulas may be associated with pelvic inflammatory disease, diverticulitis, tuberculosis, actinomycosis, and nonspecific granuloma. Apparently, technical difficulties during an operation have been responsible for some fistulas.

If the fistula arises from the small bowel, conservative treatment is often the best plan. One should always determine the location and nature of the fistula before any operative procedure is carried out. It is very important to prevent dehydration of the patient and prevent or treat excoriation of the skin about the fistulous tract. Spontaneous closure may result if conservative measures are used, but if there is obstruction distally, surgical treatment is necessary, usually a resection of the bowel. For severe excoriations of the abdominal wall, tannic acid, 5 to 10 per cent solution, has been used as a spray, with good results in many cases. The author

also makes use of a Koalin-protected pasteboard trough which is placed about the fistulous opening; the skin is covered with saline solution and water and continuous suction into the trough keeps the intestinal content off the skin. He advocated enterostomy proximal to the closure of the fistula and has utilized intraperitoneal vaccine for the prevention of peritonitis.

Gunther W. Nagel, San Francisco, Calif., stated that previous surgical operations have been a prominent cause of intestinal fistula and that the surgeon should reduce the number of these. He advocated, in addition to the foregoing regime, fresh air and sunshine.

Alton Ochsner, New Orleans, La., stressed the importance of determining the etiology of the fistula in every instance and, in addition to barium by mouth or rectum, he also recommended the introduction of lipiodol into the fistulous tract; occasionally after its injection, he has noted a cure of the fistula. For protection of the skin about the fistulous tract he has utilized bronzing powder which is made up of aluminum paint and cold cream mixtures.

Frederick A. Collier, Ann Arbor, Mich.: **Surgical Aspects of Hypoglycemia Associated With Liver Damage.**—Dr. Collier presented three cases of gall-bladder disease associated with hypoglycemia, in which hunger, coma, loss of consciousness, or symptoms of disease of the nervous system were relieved following cholecystectomy. He stated that adenomas of the pancreas, adrenal glands, or pituitary body, and disease of the liver have been reported as causes of hypoglycemia. If the hypoglycemia is not due to tumor of the pancreas, he feels that the liver should be considered as a possible cause.

The first patient was a man subject to attacks of coma, with a low blood sugar level and a glucose tolerance curve which remained elevated. This curve is similar to a diabetic curve, except that the initial level is low. At operation, his pancreas was found to be normal, without evidence of adenoma. There was an early cirrhosis of the liver and a contracted diseased gall bladder. The gall bladder was removed. The patient's glucose tolerance curve returned to normal and he had no further attacks of coma.

The second case was that of a patient who complained of hunger, polydipsia, polyuria, tremors, and weakness before meals. He had a definitely altered glucose tolerance curve, and at operation a diseased gall bladder with stones and an early interlobular hepatitis were found. Cholecystectomy was done and the patient has had no further attacks of weakness or tremor since then.

The third case was that of a patient who was subject to attacks of unconsciousness. At the end of a glucose tolerance test, he lost consciousness and had a lowered blood sugar. At operation the pancreas was negative. A diseased gall bladder with a stone was removed and the patient improved clinically thereafter and his hypoglycemia was not so marked as previously.

In these three cases tests of function showed definite damage to the liver, and the biopsies of the liver revealed cirrhosis or inflammatory infiltration.

Dr. Collier stressed the importance of the administration of glucose in operations on the gall bladder. In each of these three cases the patient's glucose tolerance curve varied from the normal, the pancreas was normal, and the carbohydrates were oxidized normally in all cases, suggesting that the pancreas did not play a part, and all the symptoms were modified by cholecystectomy.

Eunice Holman, San Francisco, Calif., stressed the importance of the administration of glucose before gall-bladder operations. It is his practice to give 100 c.c.

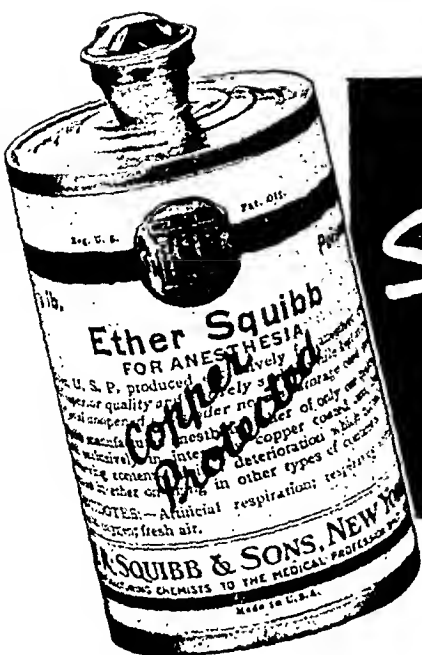
of 10 per cent solution of glucose immediately before the operation to replenish the liver glycogen because of the omission of breakfast. He felt that the good results following surgery in Dr. Collier's cases were due to better regulation of food and glucose intake rather than to cholecystectomy. He cited similar cases in which the results were good without cholecystectomy.

Frank L. Allan, Boston, Mass., stated that the patients must have a low blood sugar during their paroxysms of symptoms in order to ascribe their symptoms as being caused by hypoglycemia. In Dr. Collier's third case the blood sugar was noted to be low at the end of the glucose tolerance test, which occasionally occurs in normal persons. He did not feel that the cause of hypoglycemia can be explained by such a simple test as that of glucose tolerance when there are so many factors which affect the level of sugar in the blood stream. Damage to the liver gave the dissuasive reason for urging early operation for gallstones before injury to the liver occurs.

Theodore L. Althausen, San Francisco, Calif., cited animal experiments showing, both in animals with normal livers and in those with livers diseased by the injection of phosphorus, the protective action of glucose on the liver, and the delayed glucose tolerance curve in the animals with diseased livers. One may obtain various types of glucose tolerance curves in disease of the liver, depending on the degree of damage. He advocated the glucose tolerance test supplemented by insulin in order to accentuate differences. He stated that, in his experience, the administration of glucose in large amounts had been a factor in the reduction of postoperative mortality from cholecystectomy.

Amos R. Koontz, Baltimore, Md.: **Does Ether Narcosis Protect From Anaphylactic Shock?**—Dr. Koontz stated that there is a general impression among surgeons that ether narcosis protects the patient from anaphylactic shock, so that tetanus antitoxin is often administered under anesthesia without using the usual precaution to determine the patient's sensitivity to horse serum before the injection. A large number of guinea pigs were sensitized with various types of foreign protein. After their period of sensitization, of those which were reinjected with the same foreign protein without anesthesia, 47.8 per cent died. Of those which were injected under ether anesthesia, 18 per cent died. This definitely suggests that anaphylactic reaction is less likely to occur under ether anesthesia, but there still is danger. Ether, therefore, inhibits anaphylactic shock, but because such shock does occur in some cases, the usual precaution of cutaneous or ophthalmic tests should be used to determine whether or not the patient is sensitive to the foreign protein.

Franklin I. Harris, San Francisco, Calif., discussed the paper from a clinical standpoint. He referred to the observations of Dew, who noted that anaphylactic reactions almost never occurred when hydatid cysts were opened under ether anesthesia, but anaphylactic reaction might occur if local anesthesia, or none, was used. He also noted that reactions never occur under narcosis if blood, glucose, or saline solutions are administered intravenously, stating that there is a definite protection by the anesthetization. Nevertheless, this protection may not be complete so that it is necessary to test the patient for cutaneous reaction before he is anesthetized.



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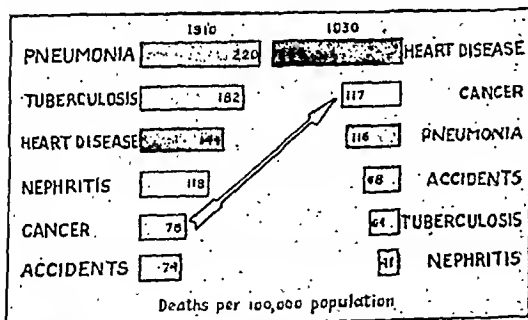
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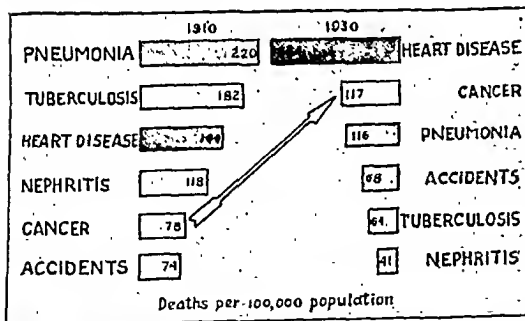
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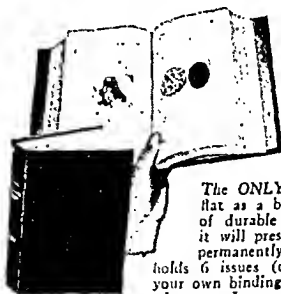
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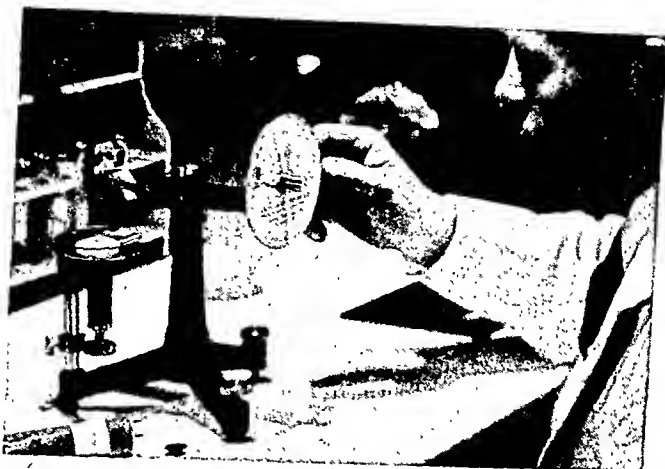
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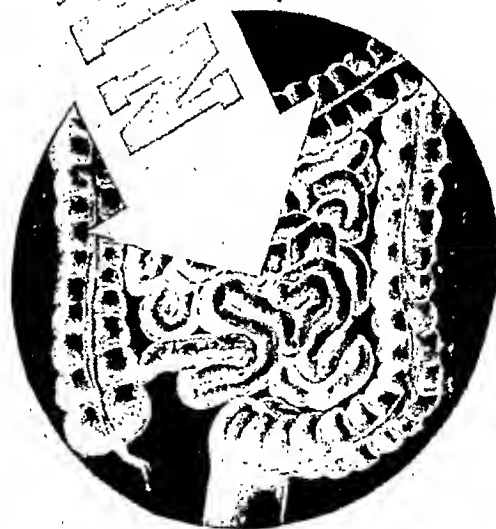
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Skin and Tension Sutures

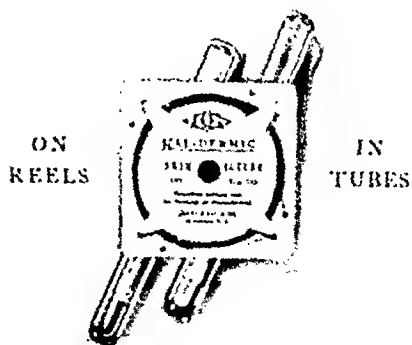


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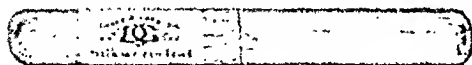


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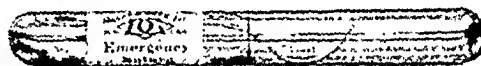
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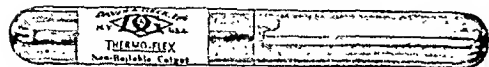
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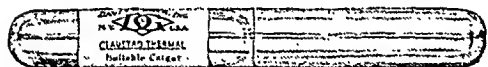
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| 1425..10-Day Chromic..... | " 5' |
| 1445..20-Day Chromic..... | " 5' |
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Sizes: 4-0 . . 000 . . 00 . . 0 . . 1 . . 2 . . 3 . . 4

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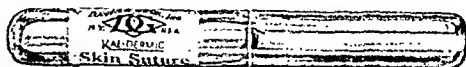
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| NO. | LENGTH |
|---------------------------|------------|
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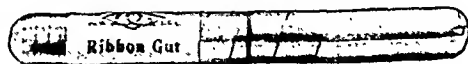
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|--------------------------|---------------|--------|
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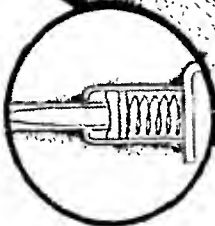


Fig. 2. Pipettes are securely mounted between rubber faced spring compression plungers and set facings.

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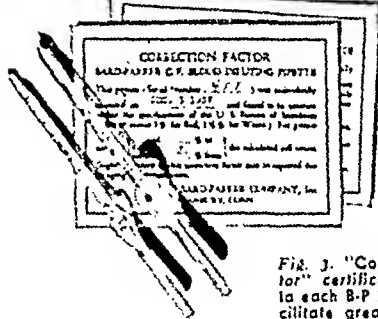


Fig. 3. "Correction Factor" certificate attached to each B-P Pipette to facilitate greater accuracy and convenience in interpretive calculation.

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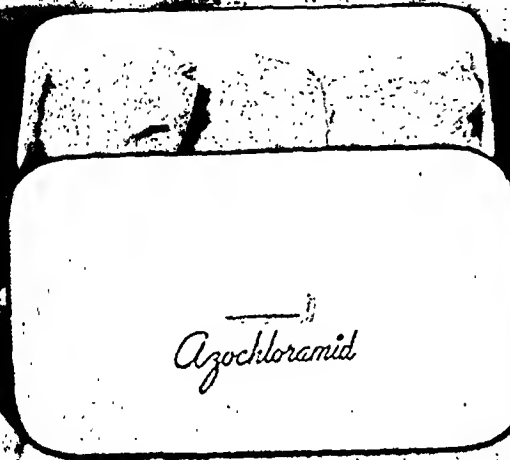
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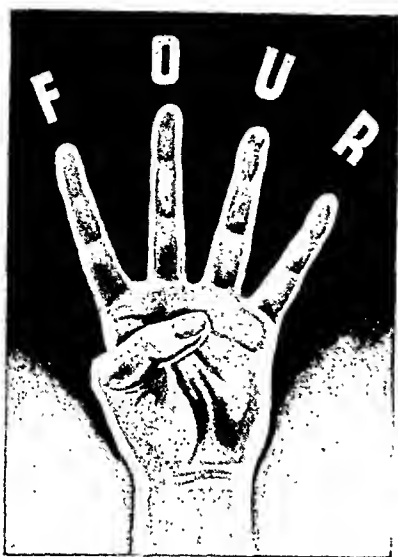
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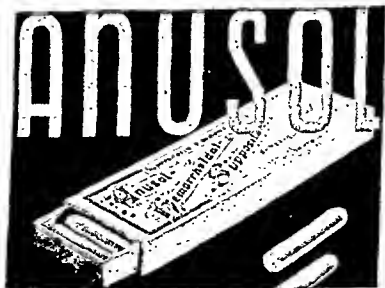
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THE TREATMENT OF PARALYTIC BLADDER IN CASES OF SPINAL CORD INJURY*

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INTRODUCTION

THE ideas which follow have not come through trial and error. Proof by my own hands of the merit of any method is wanting. In this sense is your choice of me for this address inapt. A study of the reports of those with experience, however, discloses such a difference of opinion on just what should be done for the bladder in spinal injuries that my inexperience may fit me as well as another to the task of putting the facts truthfully before you.

The problem is urological, and anyone trained in urology and so minded can find in these facts the points on which our best authorities disagree. Perhaps careful analysis will disclose to those in need, like myself, a rule of accord to serve on the rare occasion as a safe guide in the care of paralyzed bladders. This care never was a matter for general orders in any army during the World War and how much the disservice of casual treatment accounts for the death within a few weeks of 80 per cent of the 2,324 soldiers in our army who suffered injury to the spinal cord is worth pondering. Many of these men would have recovered from their nerve injuries, completely or partially, had they lived. Mostly they died, not from the injury to the spinal cord, but from the urinary complication. Although in civil life automobiles and not bullets cause most of the injuries to the spinal cord, the problem of care of the bladder is the same as in an army at war. While fatalities are fewer, they mostly follow the same complications: namely, urinary infection and bedsores on skin areas continually soiled by urine. The magnitude of the problem in every injury of the spinal cord is evident.

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One wonders to what extent the high death rate is the result of neglect of the bladder-problem through failure to realize its importance; to what extent it follows lack of knowledge and skill in the use of the methods of care, although those methods were properly chosen at the time; and to what extent it results from poor judgment in the choice of method. All of these factors may be variably responsible. The last factor implies a choice and it is on this that authorities differ. The three methods most widely advocated are: First, noneatheterization and manual expression; second, suprapubic cystostomy; and third, retention catheter.

Before discussing the relative merits of these methods, and of others which are less popular, the urological features peculiar to the problem should be made known, because a comparison of values rests largely on an understanding of this particular aspect. Authorities fail to mention this point which appeals to me as distinctively central. Perhaps each failure, as well as each success, can be accounted more to manner than to method, for, when faultlessly executed, one method may be as good as another. If this be true, the best way to treat the bladder will vary with circumstances and conditions.

The musculature of micturition and its innervation are complex and not fully understood. There are five groups of muscles innervated by three main pathways, as follows:

| <i>Smooth Muscles</i> | | <i>Autonomic Nerves</i> | |
|--|---|----------------------------|-----------------------------------|
| 1. The detrusor vesicae | } | I. The hypogastric pathway | Thoracicolubar sympathetic system |
| 2. Internal sphincter | | | |
| 3. Musculus trigonalis | | II. The pelvic pathway | Sacral parasympathetic system |
| <i>Striated Muscles</i> | | <i>Somatic Nerves</i> | |
| 4. External sphincter | } | III. The pudendal pathway | |
| 5. Accessory urethral and periueal muscles | | | |

There are five regulating centers of micturition, namely:

| | |
|-----------------------------------|----------------------|
| 1. Cerebral | Voluntary impulses |
| 2. Subcortical | } Automatic reflexes |
| 3. Lumbar | |
| 4. Sacral | |
| 5. Peripheral ganglionic plexuses | |

The voluntary impulse originates in the brain and is delivered by the midbrain to the spinal centers, instituting various nervous reflexes into automatic action. Through the hypogastric nerves from the lumbar sympathetic center flash inhibitory signals to the detrusor, and stimulating impulses to the sphincter; whereas, through the pelvic nerves from the sacral-parasympathetic center, reciprocally antagonistic impulses flow, stimulating the detrusor and inhibiting the sphincter. These

reflex impulses show an integrative activity not unlike peristalsis. The trigonalis muscle has sympathetic innervation only, no parasympathetic, so that, with sympathetic inhibitory impulses to the detrusor, flow stimulating impulses to the trigone. The striated muscles receive voluntary impulses through the pudendal nerve.

The mutual antagonism of the foregoing autonomic systems is only partial. One set does not become dominant with loss of the other. An intact parasympathetic system is more essential to function than an unbroken sympathetic pathway. In fact, hypogastric innervation may be destroyed at the periphery with little disturbance of micturition. All depends on the level, peripheral or cortical, at which the break occurs. Voluntary micturition arises from the brain, involuntary micturition from the cord, and complete dissociation gives an automatic bladder, variations of which are explained by the mutual antagonism of the sympathetic and parasympathetic systems in relation to the level at which the dissociation is made. If this level lies above the lumbar center, automaticity will be good and may be influenced reflexly by sensory impulses. Normally, tickling the sole of the foot will cause withdrawal of the foot. In the absence of this response, there is an overflow of motor impulses to other structures and it is this so-called mass reflex which causes the bladder to contract (Mayo-Robson, Kidd, Head and Riddoch). According to Holmes, the sudden increase of intra-abdominal pressure by augmenting tension within the bladder causes it to contract. He was led to this explanation by observing that contractions of the bladder always followed the abdominal spasms "by a definite interval of time, sometimes by several seconds." If the lesion in the cord is below the lumbar center, automaticity will be poor or absent and stimulation of the soles of the feet now may fail to cause this abdominal reflex and thus have no effect. Retention may follow either irritation of hypogastric fibers from the lumbar center or paralysis of the pelvic fibers from the sacral center, and incontinence comes, vice versa, with irritation of the pelvic or paralysis of the hypogastric fibers. It would be expected, therefore, that the effect on micturition will vary considerably with the level of the injury to the spinal cord. It will vary also with the type of injury. A complete transverse lesion will have a more constant and lasting effect than a partial tear—as from the laceration of a fragment of bone, or an injury without rupture of any nerve fibers—as from hemorrhage or edema with pressure on the cord. Injuries in the region of the cauda equina are notable for the marked variation in effect.

A. The Effect on Micturition.—Three phases describe the common effect on micturition of a transverse lesion at any level of the cord or cauda equina. These are: first, retention; second, overflow incontinence; and third, automatic micturition. The first phase is constant for all lesions, though variable in duration. In fractures below the

lumbar center, the other effects may be slight or absent. The phase of urinary retention commonly lasts from two to three weeks but may disappear within twenty-four hours or persist eighteen or more months. Retention, in the presence of injury at any level, is explained on the basis of "spinal shock" which isolates the bladder from its reflex centers. Complete paralysis of the detrusor and spasm of the sphincter result. Because of this spasm, catheterization usually is difficult. The picture of vesical relaxation and atony is seen cystoscopically and cystometric records all show an inert vesical wall with no "stretch" response. Reflex contractility is entirely absent. Unless infected or injured, these distended bladders never rupture spontaneously nor is there any record that the back pressure of distention ever produces hydronephrosis and renal insufficiency.

The second phase, an overflow incontinence, is of short duration and may be poorly pronounced. The detrusor gradually recovers tone, without the power of contraction however and, along with the recovery, a gradual weakening of the spasm of the sphincter occurs. In consequence, urine dribbles out as an overflow incontinence. An indwelling catheter may be repeatedly extruded and, even when retained, urine may leak around it. This may be the final phase after destructive lesions of the sacral segments or cauda equina.

The third phase is the development of an automatic bladder. With the gradual gain in muscle tone, contractility slowly returns to the detrusor and its muscle hypertrophy. Along with this recovery of the detrusor there is a return of the sphincter spasm so characteristic of the first phase. The insertion and retention of a catheter again become more difficult. A gradual recovery of the normal reaction to "stretch" is shown by cystometrograms, and the condition of automaticity develops. Automatic micturition occurs sooner and more perfectly after fractures above the lumbar center than after those below, but I can find no record of it after divisions of the cauda equina. It differs from normal micturition in the incoordination of detrusor and sphincter. Instead of being reciprocal, their activity becomes synchronous. With the return of its tone and contractility, the detrusor, in order to establish automaticity, must work against the unwonted coincidental contraction of the sphincter, and, with good automaticity, it will hypertrophy and the bladder will return to normal dimensions. So high may this initial return of tone become, sometimes, that, unless preventive measures are instituted, the capacity of the bladder will be reduced to almost nothing. The smallest amounts of urine set up emptying contractions so that the patients are as wet as in the previous phase, but for another reason. Should the detrusor fail to hypertrophy at this stage, as is likely with infection or severe toxemia, there can be no automaticity. Overdistention will persist. The detrusor will then become more and more atonic and an overflow incontinence will occur or

simply continue from the second phase. Or the condition may revert to that of retention as in the first phase. In conditions between these extremes of hypertrophy and atony of the detrusor, partial and atypical forms of an automatic bladder may occur.

The usual course of the effect on micturition of a transverse lesion of the cord at any level, therefore, is first, retention; second, overflow incontinence; and third, automaticity. These phases are most constant with complete transverse lesions above the lumbar center but, even then, are variable in duration. Variations from this course, both as to phase and duration, occur commonly with transverse lesions below the lumbar center, with partial divisions or less destructive lesions at any level, and with the advent of certain complications, such as urinary infection. True paralytic incontinence, which differs altogether from the usual picture of cord bladder, sometimes follows destruction of the lumbar centers. Automaticity never develops with destruction of sacral segments or cauda equina. With some partial lesions or injuries, there may be only delay in starting micturition, the stream may be without force and dribbling may occur at the end. In such cases normal micturition usually is soon established. The midcervical and dorsolumbar segments of the cord are injured most frequently, and therefore the three successive phases of effect on micturition are the commonest. It is well in each case to surmise, if possible, the neuromuscular background of each phase of effect in relation to the level of the cord injured and to the type of injury in the selection of any particular method of treatment. It must be obvious to all that the problem of treatment is distinctively urological.

B. The Treatment.—The information in the literature is inadequate as a guide to what should be done for the bladder in injuries of the spinal cord. There seems to be an even choice between three methods; namely: (1) noneatheterization and manual expression, (2) suprapubic cystostomy, (3) retention catheter with or without tidal irrigation.*

Each method has its particular advantages and disadvantages; each receives as much condemnation as approbation, and each has just as valid reasons against its choice as for it. The dissenting authorities are as reliable as the assenting ones. Naturally, when called to work in an open field of this kind, one who has no row of his own to hoe will hesitate which one to choose. Upon two points, however, all those with experience agree; namely, no paralyzed bladder should be left alone to distend and overflow, and, the urethral catheter should never be used casually or intermittently. Possibly this seeming paradox holds the solution to the question of a choice of method. It illustrates at least the urological aspect of the problem, and to my mind this is the problem. "The first and fatal catheter" receives sufficient castigation in the literature. On the other hand, neglect and overdistention may be fully as criminal

*The literature has been summarized in an appendix by Dr. Henry M. Weyrauch, Jr.

from the urological standpoint. Overdistention is extremely dangerous in the presence of infection, and overflow of urine means bedsores. The purpose of all treatment is to control infection and prevent bedsores. The success of any method directed to this aim, which may have to be carried on for weeks and months, depends largely on the efficiency and reliability of the personnel which will conduct it; on the nurses, relatives, orderlies, or friends to whom goes the routine of emptying the bladder by manual expression or the care of catheters and irrigations. The urologist knows that this routine care must be precise and regular. Foreknowledge that it may be wanting should influence the choice of that method least dependent on routine. But failures cannot always be assigned to mismanagement. Environment and manner of conduct are but a part of the urological problem. Patients vary in their response to method. Some tolerate a catheter poorly. Persistence in its use in the presence of urethritis, prostatitis, or epididymitis also shows poor judgment. Therefore, any precise and regular routine should still be flexible and open to change at need.

The other part of the urological problem is the condition of the bladder itself; that is, the particular neuromuscular disturbance which demands treatment. The phases of change in the disturbance of micturition can be predicted only partly by knowing the level of the injury to the cord. The succession from retention, through overflow incontinence, to final automaticity after lesions above the lumbar center may be retarded or interrupted, either partly or completely, by intercurrent infections or toxemia. Any operation for the repair of the broken back at any period of this succession may throw the condition back to the initial retention. The purpose of noncatheterization and manual expression is to hasten the development of an automatic bladder. Patients with good automaticity get along very comfortably. One side of the question then is whether this method should ever be used for patients with lesions below the lumbar center, after which automaticity is known never to develop. This is a difficult question. Retention is the initial phase for all lesions irrespective of type and level. It may not be possible to estimate immediately the extent of the lesion or its exact level and whether or not automaticity will develop. The injury, in spite of appearances, may be mild and the patient may recover quickly. The other side of the question is whether cystostomy or insertion of a catheter ever should be immediate. A catheter, whether urethral or suprapubic, means infection. It is true that this infection usually can be controlled. This, however, may be difficult. On the other hand, should urinary sepsis develop spontaneously, it may then be too late to save the patient by drainage of any kind.

The three methods grade themselves from minor to major procedures. The conservative course on patients seen immediately after injury would

be to apply them in this order, changing from minor to major according to particular indications as they arise.

On a patient seen early one would first try to empty the bladder regularly by applying pressure with the open hand above the symphysis. In doing this the bladder should not be squeezed. Should it have become too distended by delay, manual expression may cause extreme pain which may be relieved by morphine. Having the patient lie on his side may be of help, as will also pressure on the bladder through the rectum. The method works better on women. It should be applied regularly every six to eight hours, and the bladder never should be allowed to overdistend. Too prolonged an interval between expressions, by allowing overdistention, may throw the bladder back into atony with a loss of all that has been gained; but even more important than this is the likelihood that infection may get a start by reason of this neglect. The advent of infection is the one real contraindication to the use of this method. It should be looked for daily. It is dangerous to use manual expression in the presence of infection. Ascending pyelonephritis is likely and bladders have been ruptured. For a patient with clear urine, routine manual expression is safe and may lead to the rapid development of an automatic bladder. It is not the ideal procedure for all patients, nor will it always work. When infection mars its usefulness, when it fails for some other reason, when the patient has already had his bladder emptied by catheter, or when the neuromuscular phase is other than retention and unsuited to its use, one of the other two methods should be adopted promptly.

The use of a retention catheter has few advocates compared to suprapubic cystostomy. Urologists know something of the continuous care and attention required for a retained catheter. If this expert and faithful assistance is available, a retention catheter may save time, control the infection and keep the patient dry and comfortable until such time as automaticity develops. It is well to state again the fact that all authorities condemn intermittent catheterization. Recently Munro* has strongly advocated the use of tidal irrigation and claims by it to have reduced infection from 72 per cent to 14.2 per cent. Furthermore, tidal irrigations stimulate the bladder to regain contractility and therefore hasten the development of automaticity.

Suprapubic cystostomy has many advocates, most of them recent. The method gives good drainage. The care of a suprapubic tube is simple compared to that of a retention catheter. Tidal irrigations may be given through it or suction applied on occasion. Upon considering the many months that drainage may be required, the suprapubic tube has distinct advantages over the retention catheter. One possible objection is persistence of a suprapubic fistula upon development of an automatic bladder.

*The literature has been summarized in an appendix by Dr. Henry M. Weyrauch, Jr.

SUMMARY

I. It is judicious to treat each paralyzed bladder on sound urological principles.

A. There are four effects on micturition to consider: retention, overflow incontinence, automaticity, and true incontinence. In cases of fracture above the lumbar center the first three occur in succession. An automatic bladder never develops as the late and final effect after fractures below this center, and incontinence may follow destruction of the cord at this level. Partial lesions and trauma by pressure or bruising effect slight changes from the normal, usually of short duration. The "spinal shock" of any lesion at any level causes an initial paralysis of the bladder with retention. Early development of automaticity is highly desirable, but it is possible in only one group. Some methods favor this outcome more than others. Therefore, the same indication for the treatment of retention at onset notwithstanding, consideration of the probable late effects presumed by a knowledge of the level and extent of the injury should influence the choice of method.

B. Any method proves itself largely by reason of the precision and skill with which it is carried out. Some methods require more care and experience than others. Consideration of the fact that this care may be wanting also should influence the choice of method.

II. It is impractical to treat all paralyzed bladders alike.

A. Some do best if left alone or, at most, emptied regularly by manual expression. Others get along satisfactorily with retention catheters irrigated periodically or continuously (tidal); and still others require cystostomy for drainage.

B. Urinary infection and bedsores foil the outcome to a maximum of over 80 per cent. The intent of all care, therefore, is to prevent or control these two evils.

C. Noncatheterization, with manual expression and antiseptic therapy, is the one way to ward off urinary sepsis. When it works, it is the best method to hasten automaticity. It is useless and dangerous as a method to control infection. If infection is present, the choice between catheter per urethram, and cystostomy must be made at once. Even before infection takes place drainage by one means or the other often proves superior.

III. The care of the bladder after injuries to the spinal cord should be prompt, precise, and farsighted. To be successful, rare judgment and constant attention are required. Most of these patients, in spite of all effort, die of or with severe urinary infection.

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Supplementary Bibliography

I. BIBLIOGRAPHY OF THE PRINCIPLES OF TREATMENT

A. *Noncatheterization and the Use of Manual Expression.*—

Advocated by: Heddaeus,⁴² 1888; Chico,¹⁵ 1889 (who practiced it in 1874); Besley,⁵ 1917 (experience in Base Hospital, France); Vellacott and Webb-Johnson,⁸³ 1919 (experience in British war hospital); Plaggemeyer,⁷²⁻⁷⁴ 1919, 1921 (experience with American army in World War); David,²² 1921; Cumming,¹⁹ 1922 (United States Army); Cahill,¹³ 1928; Gurdjian,³⁵ 1931; Connors and Nash,¹⁷ 1934 (54 cases).

Reasons for: 1. Prevents urinary tract infection.

2. Best method for the rapid development of an automatic bladder. Many patients with spinal injury can be saved if they do not succumb to urinary tract infection. By this method there is no damage to the kidneys and there is no danger of spontaneous rupture of the bladder.

Method condemned by: Kidd,⁴⁸ 1919; Boyd,⁹ 1929.

Reasons against: 1. Hematogenous infection will result if patients are not catheterized.

2. Method is time-consuming in way of nursing care.

3. Urine will soil bed and cause bed sores.

B. *Retention Catheter.*—1. *Without Tidal Irrigation.*—

Advocated by: Kidd,⁴⁸ 1919 (war experience); Gurdjian,³⁵ 1931 (if infection is present).

Reasons for: 1. It saves time.

2. It avoids overdistention of the bladder.

3. It reduces infection to a minimum.

4. Skin is not soiled by urine; prevents bed sores.

5. Calculi do not form.

6. Urethra not damaged by frequent catheterizations.

7. Paves the way to an automatic bladder.

Condemned by: Drapier,²⁶ 1919; Connors and Nash,¹⁷ 1934.

Reasons against: 1. Invariably leads to infection.

2. Not effective method of drainage; frequent clogging of catheter from clots.

2. *Retention Catheter With Tidal Irrigation.*—

Advocated by: Munro,⁷⁰ 1937 (has reduced urinary tract infection from 72 per cent to 14.2 per cent); Young,⁹¹ 1926 (recommends decompression apparatus with mild antiseptic).

Reasons for: 1. Prevents overdistention of bladder.

2. Reduces infection.

3. Facilitates development of an automatic bladder.

C. *Suprapubic Cystostomy.*—

1. Early.

2. In presence of urinary tract infection.

Advocated by: Thompson Walker,⁸⁰ 1917 (no experience with method advised); Mayo-Robson,⁶³ 1917; Drapier,²⁶ 1919; Wertheimer,⁸⁸ 1924 (experience in French army); Boyd,^{8,9} 1927, 1929; Wallenstein,⁸⁶ 1931; Edwin Davis (personal communication to Munger,⁶⁸ 1937); Deming (personal communication to Munger,⁶⁸), 1937.

With exception: Esau,²⁹ 1921, if severe bladder infection; David,²² 1921, as a last resort; Connors and Nash,¹⁷ 1934, if expression painful or bladder overdistended; Creevy,¹⁸ in selected cases; Munger,⁶⁸ 1937, if expression method is unsatisfactory.

Reasons for: 1. Prevents overdistention of bladder.

2. Prevents severe infection of bladder.

3. Prevents ascending infection.

4. Permits adequate drainage (large tube, simple to irrigate).

5. Economical in time of nurses.

The suprapubic fistula will heal and an automatic bladder develop, if desired. Hematogenous infection of urinary tract will result even though the patient is not catheterized. Continuous bladder irrigation may be instituted if so desired.

Condemned by: Kidd,⁴⁸ 1919; Vellacott and Webb-Johnson,⁸³ 1919; Young,⁹¹ 1926.

- Reasons against: 1. Difficult to care for from nursing viewpoint.
 2. Severe infection of the urinary tract following use of the method is the rule rather than the exception.
 3. Bladder calculi likely to form.
 4. If automatic bladder develops, practically impossible to get fistula to close.
 5. Difficult to keep drainage tube water-tight (leakage causes bed sores).
 6. Bladder is permanently damaged.

D. Intermittent Catheterization.—

Advocated by: None.

Condemned by: Drapier,²⁶ 1919; Kidd,⁴³ 1919; Plaggemeyer,^{72, 73} 1919; Curtis,²¹ 1919; David,²² 1921; Cumming,¹⁹ 1922; Young,²¹ 1926; Cahill,¹³ 1928; Boyd,⁹ 1929; Connors and Nash,¹⁷ 1934; Wesson,⁸⁹ 1934.

- Reasons against: 1. Traumatizes urethra.
 2. Causes prostatitis, seminal vesiculitis, and epididymitis.
 3. Invariably results in urinary tract infection.
 4. Fails to keep bladder empty; danger of overstretching wall.
 5. Leakage between catheterizations predisposes to bed sores.

E. Distention and Overflow.—

Advocated by: None.

Condemned by: Vellacott and Webb-Johnson,⁸³ 1919.

- Because: 1. Pain may be severe.
 2. Distention of bladder may embarrass respiration and cardiac action, an important factor in hemothorax.
 3. Shock may be induced by allowing distention of bladder.
 4. Doubt whether bladder will ever regain tone.
 5. Hematuria, vesical in origin, may ensue.
 6. Extremely dangerous if infection is present.

F. Suprapubic aspiration in preference to catheterization if intervention is necessary.

Advocated by: Plaggemeyer,^{72, 73} 1919.

Reason: Will avoid infection.

G. Presacral Sympathectomy.—

Advocated by: Learmonth,^{59, 59} 1931; McCrea and McDonald,⁶⁵ 1934; Creevy,¹⁸ 1936; Grant,³³ 1936 (reports case following spine injury; patient died).

Condemned by: Braasch,¹⁰ 1934.

H. Instrumental Dilatation of the Urethra.—

Advocated by: Vellacott and Webb-Johnson,⁸³ 1919.

Reason: Produces temporary incontinence until automatic bladder develops.
 No cases.

(Braasch¹⁰ advocated method in atonic bladders, 1934.)

I. Nerve Transplantation to Paralyzed Bladder.—

Trumble⁸² (experimental), 1935.

J. Sinusoidal Stimulation of Bladder.—

Cumming,¹⁹ 1922 (serious complications in 2 cases; no details).

Supplementary Forms of Treatment.—

1. Urinary antiseptics.
2. Drugs which act through sympathetics and parasympathetics.
3. Drugs acidifying urine to prevent calculus formation and reduce infection.
4. Prostatic massage and urethral dilations to reduce obstruction.
5. Bladder irrigations to reduce infection.
6. Instillation of irritating drugs to cause bladder to regain tone.
7. Autogenous vaccine to combat infection.

II. NEUROANATOMY, PHYSIOLOGY, AND PATHOLOGY OF MICTURITION

Dubois,³⁷ 1876; Maso and Pellacani,⁶ 1882; Born,⁷ 1886; Guyon,²⁷⁻²⁹ 1889, 1891, 1900; von Zeissl,^{84, 85} 1896, 1901; v. Frankl-Hochwart,³¹ 1898; Elliott,^{27, 4} 1907; Schwarz,⁷⁸ 1916; Fearnside,⁵⁰ 1917; Head and Riddoch,⁴¹ 1917; Thompson Walker,⁸⁰ 1917; Adler,³ 1918; Muller,⁶⁷ 1918; Stavianicek,⁷⁹ 1918; Barrington,^{3, 4} 1921, 1923; Langley,⁵⁰ 1921; Elberg,⁷⁸ 1926; Potter,⁷⁵ 1926; McClintie,⁶⁴ 1928; Kettle,⁴ 1930; Gurdjian,²³ 1931; Learmonth,⁵⁹ 1931; Denny-Brown,^{24, 25} 1933; Holmes,⁴⁵ 1933; Gruber,³⁴ 1933; Karschulin,⁴⁷ 1933; Langworthy,³¹⁻³⁴ 1933, 1934, 1935; Connors and Nash,¹⁷ 1934; Grant,³³ 1936; Lewis and Dees,⁶¹ 1936.

III. EFFECT OF LEVEL OF CORD INJURY ON MICTURITION

Thompson Walker,⁸⁰ 1917; Adler,¹ 1918; Plaggemeyer,^{72, 73} 1919; Barrington,³ 1921; Elsberg,²⁸ 1926; Denny-Brown,²⁵ 1933; Holmes,⁴⁵ 1933.

IV. PHASES IN BLADDER DISTURBANCE FOLLOWING CORD INJURY AND EFFECT OF SEVERE TOXEMIA

Head and Riddoch,⁴¹ 1917; Thompson Walker,⁸⁰ 1917; Plaggemeyer,^{72, 73} 1919; Vellacott and Webb-Johnson,⁸³ 1919; Denny-Brown,²⁵ 1933; Holmes,⁴⁵ 1933; Munro,⁷⁰ 1937.

V. CYSTOSCOPIC PICTURE

Caulk,¹⁴ 1919; Plaggemeyer,^{72, 73} 1919; Cumming,²⁰ 1932; Lewis and Dees,⁶¹ 1936.

VI. ETIOLOGY AND CONSIDERATION OF INFECTION OF URINARY TRACT SECONDARY TO SPINAL CORD INJURY

Thompson Walker,⁸⁰ 1917; Curtis²¹ (experimental), 1919; David²² (experimental), 1921; Boyd,⁹ 1929; Cumming,²⁰ 1932; Connors and Nash,¹⁷ 1934.

VII. CONSIDERATION OF HEMATURIA

Vellacott and Webb-Johnson,⁸³ 1919.

VIII. EFFECT ON KIDNEYS OF CORD BLADDER SECONDARY TO SPINE INJURY

Curtis²¹ (experimental), 1919; Cumming,^{19, 20} 1922, 1932; Cahill,¹³ 1928; Hepler,⁴⁴ 1933.

IX. EFFECT ON URETERS

Fullerton,³² 1919; Kreutzmann,⁴⁹ 1928.

X. RECTAL SPHINCTER PARALLELS URINARY

Plaggemeyer,⁷⁴ 1921; Creevy,¹⁸ 1936.

XI. SEX FUNCTION (IN CORD INJURY)

Plaggemeyer,⁷⁴ 1921; Cumming,¹⁹ 1922.

XII. PRIAPISM (FOLLOWING CORD INJURY)

Hartwell,⁴⁰ 1917.

XIII. FOLLOW-UP RESULTS—STATE OF AUTOMATIC BLADDER

Plaggemeyer,⁷⁴ 1921; Cumming,¹⁹ 1922; Hepler,⁴⁴ 1933.

XIV. PROGNOSIS

Drapier,²⁶ 1919; Connors and Nash,¹⁷ 1934; Creevy,¹⁸ 1936.

TUMORS OF THE KIDNEY WHICH INVADE THE INFERIOR VENA CAVA

A REPORT OF SEVEN CASES

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INVASION of the venous circulation by malignant tumors which originate in the kidney occurs with surprising frequency. Judd and Scholl in a study of 200 renal tumors found that 22.5 per cent had invaded the renal vein. More extensive invasion of the venous circulation with involvement of the inferior vena cava occurs much less frequently. Excellent studies of case reports of this type of lesion have been made by Pleasants, Simpson, Jacobson, and Goodpasture. Simpson in 1924 collected 32 cases in which a renal tumor had involved the inferior vena cava. Two additional cases have been reported since that time; these cases and the 7 cases included in this report bring the total to 41.

Investigators of this subject have complained that the nomenclature of renal tumors in older reports interferes with an accurate classification of the type of tumor. It is probable that recent literature has merely added to this confusion for two reasons: first, the controversy over the Grawitz theory has led to the use of a number of different names for the so-called hypernephroma; and second, the well-known polymorphism of this type of tumor has led many authors to classify peculiar examples as "perithelioma," "sarcoma" or "endothelioma." However, at the Mayo Clinic we usually refer to the Grawitz tumor as "carcinoma" and will so designate the seven tumors which form the basis of this report.

It is apparent that nearly all types of malignant renal tumors are capable of invading the renal vein and inferior vena cava. This was demonstrated by Engelken and Rosenstein, who have reported cases in which such involvement occurred; in these cases the patients were children and the tumors were sarcomas. Taddei reported a case in which the tumor was a squamous-cell carcinoma of the renal pelvis, and Turner and Velpeau have reported cases in which the renal tumor was a metastatic growth.

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In the 34 cases of tumorous invasion of the inferior vena cava reported previously, the tumors occurred predominantly among males (28 cases) and occurred more often in the right kidney (20 cases). It was suggested by Pleasants that the shorter renal vein on the right side may possibly give the tumor easier access to the inferior vena cava. The tumorous thrombosis extended into the right auricle in 16 of the 34 cases.

Symptoms are often obscure and it is apparent that diagnosis is usually either established or completed at necropsy. Edema or ascites or both occurred in 24 of the reported cases, and pain of varying degree, character, and situation occurred in 21 cases. The presence of the most helpful indication of obstruction of the inferior vena cava, namely, engorgement of the collateral superficial veins, was noted as present in only 11 cases. However, the absence of this sign was noted in 13 cases. Hematuria, which is a helpful indication of renal tumor, was noted as present in 10 cases and as absent in 11 cases. Its presence or absence was not indicated in 13 cases.

Comments concerning the collateral circulation that is quickly established when the inferior vena cava is obstructed have been made by both Simpson and Pleasants. It is indeed amazing that compensation for complete obstruction can occur with such a paucity of physical signs. In several reported cases obstruction of the hepatic veins has occurred and has produced icterus. In one case reported, obstruction of the portal vein also was present. Woodruff and Levine have suggested diagnostic methods which may be of value in establishing the presence of venous obstruction. None of these procedures was used in our cases. Unfortunately, in some cases either tumorous thrombosis or a superimposed simple thrombosis descends into the iliac veins. In such cases these methods probably would not enable one to make a positive diagnosis of obstruction of the inferior vena cava. However, because of the high incidence of tumorous thrombosis in cases of obstruction of the inferior vena cava (24.8 per cent, according to Pleasants) and owing to the high incidence of renal tumors in cases of tumorous thrombosis (50 per cent, according to Simpson), the use of these methods is suggested in cases in which a renal tumor is suspected, but the symptoms are obscure. Sudden death sometimes occurs in cases in which tumorous thrombosis involves the heart. In such cases death is caused by obstruction of the tricuspid valve or by pulmonary embolism resulting from the tumorous thrombosis or the superimposed simple thrombosis.

REPORT OF CASES

CASE 1.—A white man, aged 56 years, came to the clinic because of ascites and edema of the legs. The initial symptom had been a mild edema of the feet which had occurred at night. This symptom first had been noted five months before the

patient came to the clinic. Examination had disclosed that the liver was enlarged. A week after the appearance of the edema, thrombophlebitis of the right leg had developed; the patient had been confined to bed for seven weeks. Four months before he came to the clinic, severe hematuria had occurred; the severe hematuria had lasted only one day and the blood in the urine had disappeared promptly. After this the edema of the feet had improved but had not disappeared entirely. Three weeks before the patient came to the clinic ascites had developed; this had increased in severity and had caused a gain of 23 pounds (10.4 kg.). At the same time the edema of the legs had become much worse than it had been. Ten days before he came to the clinic, 2,000 c.c. of ascitic fluid had been removed by abdominal paracentesis.

Examination at the clinic disclosed definite ascites. The superficial veins of the abdomen were moderately dilated. There was moderate edema of the genitals and over the sacrum. There also was marked edema of both legs. The liver was palpable 10 cm. below the right costal margin. The concentration of hemoglobin was



Fig. 1.—Tumor thrombus (Case 1) extending from right renal vein into inferior vena cava and left renal vein; tumor thrombosis extends upward, induced thrombosis extends downward from a distance 2 cm. below entrance of right renal vein. The aorta is opened below the left renal vein.

91 per cent; there were 4,020,000 erythrocytes and 7,000 leucocytes in each cubic millimeter of blood. A roentgenogram of the thorax did not disclose any abnormality. The value for the urea was 44 mg. per 100 c.c. of blood. Urinalysis revealed a few erythrocytes. The bromsulphalein test disclosed moderate impairment of liver function. The electrocardiogram disclosed right ventricular preponderance.

Two days after the patient came to the clinic, abdominal paracentesis was performed and 2,100 c.c. of fluid was removed. Four days later the patient went into a state of shock and died.

Necropsy disclosed slight edema of the ankles. The peritoneal cavity contained 25 c.c. of ascitic fluid. The right kidney weighed 745 gm. Its lower pole had been replaced completely by soft yellowish tumor tissue. The surface of the kidney was coarsely nodular. In several places cauliflower-like masses of tumor

tissue had perforated the renal capsule. The tumor measured 12 by 6 by 7 cm. and was very friable. Its cut surface was yellowish-red. The upper half of the kidney contained metastatic nodules; approximately 95 per cent of the substance of the kidney had been replaced by the tumor. The tumor extended into the right and left renal veins and the inferior vena cava. Friable tumor tissue extended downward in the inferior vena cava for a distance of 2 cm. (Fig. 1). Below this tumorous thrombosis was a simple thrombosis which extended downward into both iliac veins. The latter had a homogeneous or laminated appearance and was grayish red. The tumorous thrombosis extended upward beyond the hepatic veins; it extended into the right auricle and through the tricuspid valve and into the right ventricle. It was firmly attached throughout its extension in the inferior vena cava. In the right auricle and right ventricle the tumorous thrombosis was loosely adherent and was attached only to the anterior wall of these chambers. The pulmonary valve was partly occluded by the tumorous thrombosis, but there was no evidence of pulmonary embolism.

The liver weighed 1,820 gm. and was reddish brown. The consistency of the right lobe was increased slightly. Metastatic nodules were present in the right and left lobes of the liver. There was diffuse chronic passive congestion of the liver; this was particularly marked in the right lobe. The collateral circulation was not marked in the body; this possibly might be attributable to the fact that the body had been embalmed before the necropsy was performed. There was evidence of venous engorgement throughout the small intestine.

Histologic examination disclosed that the tumor was a papillary carcinoma (hypernephroma); however, it contained fewer clear cells than usually are found in this type of tumor.

CASE 2.—A white woman, aged 33 years, first came to the clinic Aug. 23, 1936, because of intermittent attacks of epigastric distress which had been relieved by food or alkalis. A roentgenogram of the stomach and duodenum revealed a duodenal ulcer, and the patient was instructed in a medical regimen for the ulcer. The patient came to the clinic again on Nov. 23, 1936, because of irregular and excessive menstruation. A dilatation and curettage revealed an atrophic cystic menopausal type of endometrium. At the time of this visit to the clinic the patient complained of swelling of the left leg. The swelling of the leg had been present for only a few days. The edema of the left leg persisted and in the first part of February, 1937, edema also developed in the right leg.

The patient was seen again on Feb. 24, 1937, and a diagnosis of acute perforation of a duodenal ulcer was made. Operation was performed immediately and the perforation was closed. At this time (Feb. 24, 1937), it was noted that the edema of both legs had increased.

Examination on Feb. 24, 1937, revealed a pale and obviously very ill woman who was having severe pain. Examination of the abdomen revealed rigidity and excruciating tenderness over the entire abdomen. There was a severe edema present over both legs and over the sacrum. The edema was greatest over the left leg. Examination of the heart and lungs was essentially negative except for the rapid pulse rate. The values for the blood pressure were 100 mm. of mercury systolic and 68 mm. diastolic. During the patient's stay in the hospital from Feb. 24, 1937, to April 21, 1937, the concentration of hemoglobin ranged from 79 to 89 per cent; the erythrocyte count ranged from 3,820,000 to 4,380,000 per cubic millimeter, and the leucocyte count ranged from 9,200 to 16,600 per cubic millimeter of blood. A roentgenogram of the thorax did not disclose any abnormality. The flocculation tests for syphilis were negative. The value for the urea ranged from 20 to 40 mg. per 100 c.c. of blood. Fifteen urinalyses revealed erythrocytes in the urine on only one occasion, and on that occasion only an occasional erythrocyte was found in the urine. There were pus cells in the urine on several occasions.

On Feb. 28, 1937, four days after the closure of the perforated duodenal ulcer, jaundice developed; this persisted for several days. On March 2, 1937, six days after the duodenal operation, a severe ascites developed. This necessitated a re-opening of the incision, which drained serous fluid for several days. The patient had a parotitis on the left side on March 6, 1937; this subsided after treatment with radium. On March 16, 1937, the patient began having large, foamy, yellow stools which were thought to be due to a pancreatitis; this intestinal condition cleared up spontaneously within a few days. Throughout her entire postoperative course the patient's pulse rate ranged from 100 to 140 although her temperature was never more than 100° F.; the patient had continued to have persistent edema of the legs and the sacrum and a marked ascites with dilatation of the superficial abdominal veins. The ascites and edema were partially controlled by frequent injections of

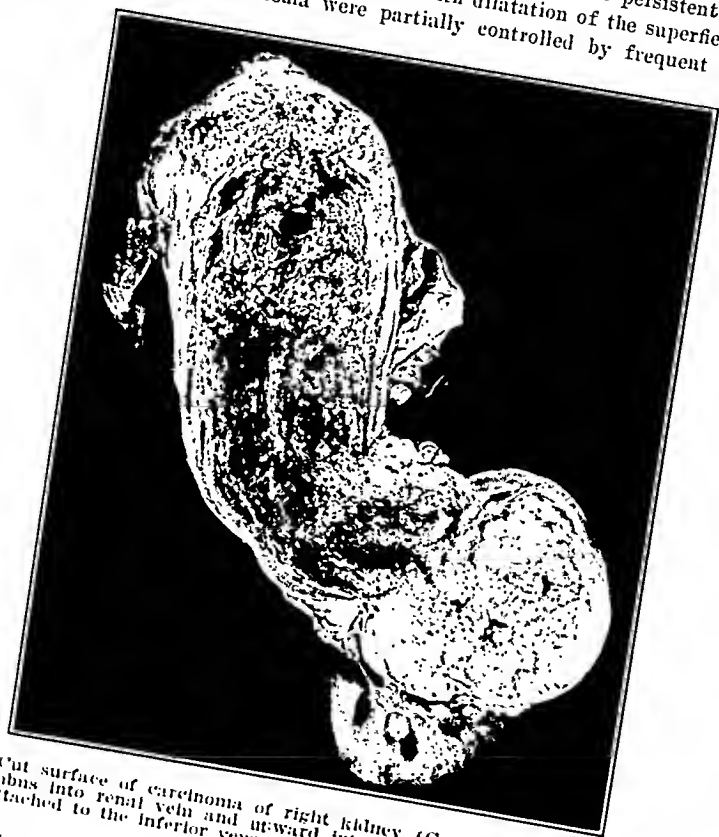


FIG. 2.—Cut surface of carcinoma of right kidney (Case 2) showing extension of tumor thrombus into renal vein and upward into inferior vena cava. Tags of liver tissue are attached to the inferior vena cava at the top of the specimen.

salysrgan and restriction of the fluid intake. The patient was dismissed from the hospital on April 21, 1937. The patient was seen at frequent intervals at her home; the injections of salysrgan were continued and the fluid intake was restricted. Despite these measures the ascites increased; on May 8, 1937, a paracentesis was performed and 1,200 c.c. of clear bile-colored fluid was removed. Following this, the patient continued with very little change until June 24, 1937, when chills and fever developed; the patient became cyanotic and died on June 28, 1937. Necropsy disclosed a definite edema of the feet and legs. The skin was slightly icteric. There was a ventral hernia in the upper part of the abdomen in which the hernial sac was distended to 23 by 21 cm. in diameter. The peritoneal cavity contained 7 liters of clear yellow fluid. The right kidney weighed 500 gm. The upper

two-thirds of this organ was occupied by a fibrous encapsulated yellowish-red tumor which measured 8 by 6 by 6 cm. and communicated directly as a tumor thrombus with the renal vein (Fig. 2). This vein measured 7 cm. in diameter. Approximately 50 per cent of the substance of the right kidney had been replaced by the tumor. The left vein was not thrombosed. The tumor thrombus extended directly from the right renal vein into the inferior vena cava which was distended

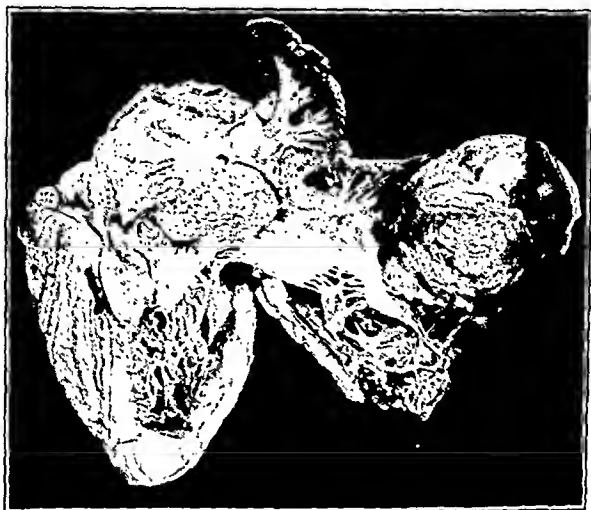


Fig. 3.—Tumor thrombus in left auricle (Case 2); continuity with the tumor thrombus in the inferior vena cava was severed along the rough round area on the lower surface of the mass. The tumor also was attached to the roughened surface of the interauricular septum.

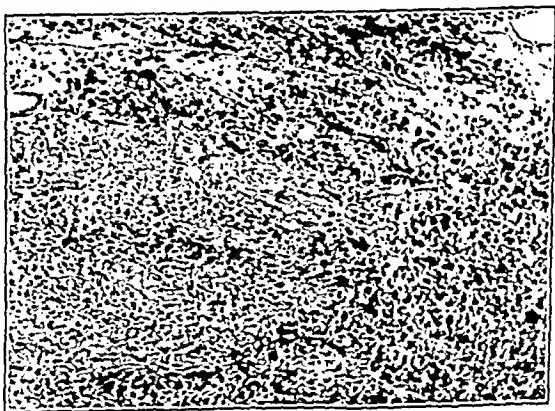


Fig. 4.—Microscopic appearance of the tumor in Case 2; one may note the general resemblance to sarcoma; the cells to left of the center closely resemble clear epithelial cells of renal carcinoma; specimen stained with hematoxylin and eosin ($\times 95$).

to a diameter of 9 cm. (Fig. 3). The tumorous thrombosis extended upward into the right auricle where it formed a mass 6 by 5 by 4 cm. This mass was firmly attached to the auricular endocardium, and obstructed the opening of the tricuspid valve at least 95 per cent. There was no pulmonary embolism.

The liver weighed 2,100 gm. and was dark red. Severe chronic passive congestion was present. The hepatic veins were not thrombosed. There were marked varicos-

ities in the lower part of the esophagus. The stomach contained 50 c.c. of dark, red, partially digested blood. Both right and left femoral and iliac veins were thrombosed. There were scars on the anterior and posterior walls of the first portion of the duodenum, and a contracted line of scar tissue joined the two scars. The anterior scar appeared on the serosa and was apparently the point of the former perforation. There was no active ulcer.

Histologic examination disclosed that the tumor was pleomorphic and vascular. It contained many regions of necrosis and hemorrhage (Fig. 4). The cells were of various sizes and shapes and contained hyperchromatic nuclei. There was no well marked stroma or pattern of arrangement of the cells of the tumor. In some regions there was a honeycomb appearance of a group of contiguous cells in which the cytoplasm was clear. This appearance resembled that of vegetable fibers and was the only characteristic of renal carcinoma found microscopically. It is possible that an unequivocal histologic diagnosis of carcinoma is subject to question and that some pathologists might call this tumor a sarcoma. It is our opinion, however, that, since renal tumors are notoriously pleomorphic in microscopic appearance, we can accept this tumor as a carcinoma (hypernephroma) with poor histologic differentiation.

CASE 3.—A white man, aged 62 years, came to the clinic because of recurrent attacks of right renal colic and associated dysuria. The first attack had occurred seven years before the patient came to the clinic. On one occasion hematuria had occurred. Examination at the clinic disclosed a palpable, indefinite, fixed mass in the right renal region. Urinalysis revealed a few erythrocytes and a few pus cells. A pyelogram revealed a tumor of the right kidney. Operation disclosed a large adherent renal tumor that extended into the right renal vein. The patient died fourteen days postoperatively. Necropsy disclosed metastatic involvement of the liver, lungs, and adrenal glands. The carcinoma extended into the right renal vein and the inferior vena cava to the level of the diaphragm.

CASE 4.—A white man, aged 46 years, came to the clinic because of intermittent hematuria. The hematuria had been first noted five years before the patient came to the clinic. The patient had had urinary frequency and dysuria and a mild pain in the back, which had been more severe on the right side and had been associated with the attacks of hematuria. Roentgenographic examination had disclosed a tumor of the right kidney two years before the patient came to the clinic. Examination at the clinic disclosed a moderately enlarged right kidney. Urinalysis revealed occasional erythrocytes and a few pus cells. A pyelogram revealed a tumor of the right kidney. A large renal tumor, which extended beyond the midline and was fixed to the spinal column, aorta and vena cava was found at operation. Pneumonia developed and the patient died fifteen days after the operation. Necropsy disclosed that the carcinoma had extended into the right renal vein and the inferior vena cava. There was metastatic involvement of the liver, lungs, and the adrenal glands on the right side.

CASE 5.—A white man, aged 72 years, came to the clinic because of epigastric pain, constipation, and continued loss of weight (37 pounds). These symptoms first had been noted three months before the patient came to the clinic. A day after the patient came to the clinic, severe generalized abdominal pains and persistent vomiting developed. The patient was treated conservatively. There was no history of any urinary symptoms. The results of examination at the clinic were essentially negative except for slightly dilated varicosities of the lower extremities. Urinalysis revealed numerous erythrocytes and an occasional pus cell. Because of the persistent intestinal obstruction, an ileostomy was performed five days after the patient came to the clinic. The patient continued to fail and died

two-thirds of this organ was occupied by a fibrous encapsulated yellowish-red tumor which measured 8 by 6 by 6 cm. and communicated directly as a tumor thrombus with the renal vein (Fig. 2). This vein measured 7 cm. in diameter. Approximately 50 per cent of the substance of the right kidney had been replaced by the tumor. The left vein was not thrombosed. The tumor thrombus extended directly from the right renal vein into the inferior vena cava which was distended

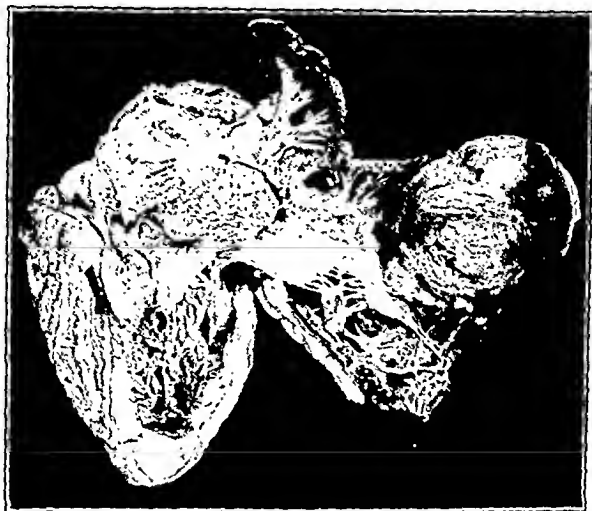


Fig. 3.—Tumor thrombus in left auricle (Case 2): continuity with the tumor thrombus in the inferior vena cava was severed along the rough round area on the lower surface of the mass. The tumor also was attached to the roughened surface of the interauricular septum.

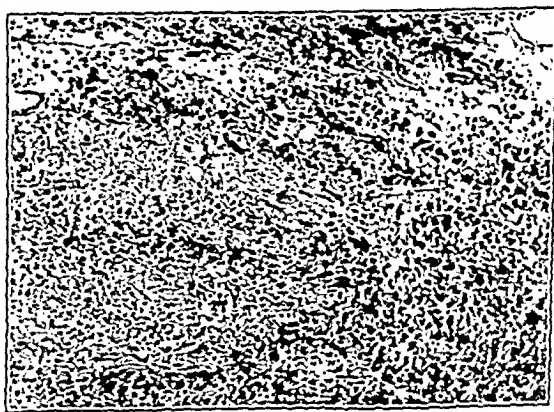


Fig. 4.—Microscopic appearance of the tumor in Case 2; one may note the general resemblance to sarcoma; the cells to left of the center closely resemble clear epithelial cells of renal carcinoma; specimen stained with hematoxylin and eosin ($\times 95$).

to a diameter of 9 cm. (Fig. 3). The tumorous thrombosis extended upward into the right auricle where it formed a mass 6 by 5 by 4 cm. This mass was firmly attached to the auricular endocardium, and obstructed the opening of the tricuspid valve at least 95 per cent. There was no pulmonary embolism.

The liver weighed 2,100 gm. and was dark red. Severe chronic passive congestion was present. The hepatic veins were not thrombosed. There were marked varicos-

were essentially negative except in Case 2, in which the patient had a persistently high pulse rate. The lack of cardiac symptoms is similar to the lack of symptoms found in chronic constricting pericarditis. The similarity is further shown by the fact that they both give rise to the same mechanical embarrassment of the heart, namely, an inflow stasis.

Thrombosis of the hepatic vein was present in one case (Case 1). In this case metastatic nodules also were present in both right and left lobes of the liver; the liver was enlarged and the bromsulphalein test revealed moderate impairment of liver function. There was no history of jaundice. In another case (Case 2) the jaundice developed four days after operation for a perforated duodenal ulcer. The jaundice was present for several days but cleared up spontaneously. In this case, the hepatic veins were not thrombosed, and there was no evidence of metastatic involvement of the liver; the only finding was a severe chronic passive congestion of the liver. We are unable to explain the presence of jaundice in this case. However, jaundice of unknown origin is not infrequently seen in severe intra-abdominal accidents, such as perforated duodenal ulcer, and the jaundice in this case may have been on the same basis.

The most striking feature in the 7 cases reported is the lack of clinical symptoms. In the first 2 cases (Cases 1 and 2) the diagnosis of thrombosis of the inferior vena cava was suggested, but was not made definitely until necropsy. In one case (Case 2) there were no symptoms that were suggestive of a renal affair at any time and it is significant that a renal tumor can be so extensive and produce no renal symptoms. In another case (Case 5) the renal tumor with extension to the inferior vena cava was an incidental finding and did not directly contribute to the death of the patient.

The classic signs of obstruction of the inferior vena cava, namely, engorgement of the superficial veins, edema, and ascites, were present in only 2 cases. In the remaining 5 cases these signs were not present. One, therefore, must conclude that with our present diagnostic facilities and knowledge it is very difficult to make a clinical diagnosis of obstruction of the inferior vena cava and in most instances the diagnosis must be made at necropsy.

SUMMARY

Edema, ascites, and engorgement of the collateral superficial circulation, which would indicate the presence of obstruction of the inferior vena cava, were present in only 2 of the 7 cases. Extension of the tumor thrombus into the right atricle occurred in 2 cases. Thrombosis of the hepatic veins and metastatic involvement of the liver with impaired liver function occurred in 1 case.

thirty-five days after the operation. The patient's condition was too critical to warrant any further urologic investigative procedures. Necropsy disclosed a carcinoma (hypernephroma) of the right kidney which had extended into the inferior vena cava. There was metastatic involvement of the liver and lungs. The intestinal obstruction was not related to the renal carcinoma.

CASE 6.—A white man, aged 60 years, came to the clinic because of a sensation of fullness over the right side of the abdomen and recent slight loss of weight. The sensation of fullness over the right side of the abdomen first had been noted four years before the patient came to the clinic. Examination at the clinic disclosed a large, fixed right kidney. Urinalysis revealed a few erythrocytes and a few pus cells. Excretory urograms and a right pyelogram revealed a tumor of the right kidney. Operation disclosed a large renal tumor which was adherent to the surrounding structures and had extended into the inferior vena cava and to the retroperitoneal portion of the duodenum. The patient died fifteen days after the operation. Necropsy disclosed that the carcinoma (hypernephroma) had extended into the right renal vein and the inferior vena cava, 3 cm. above the renal vein. There was tumorous embolism of the lungs.

CASE 7.—In this case the patient never was examined at the clinic. Necropsy only was done. The patient was a white woman, aged 71 years, who had died suddenly. Her relatives said the patient had had hematuria for two months and that she had had an enlarging mass in the left jaw for three weeks before she died. No other data were available. Necropsy disclosed a carcinoma (hypernephroma) of the left kidney. The tumor had extended into the right renal vein and the inferior vena cava. There was metastatic involvement of the lungs.

COMMENT

The findings in these 7 cases are in accord with the findings of the 34 cases that have been reported in the literature. In 5 of the 7 cases the patients were men, and in 28 of the 34 cases previously reported the patients also were men. In 6 of the 7 cases the tumor was on the right side and it appeared on the right side in 24 of the cases previously reported. Edema or ascites was present in only 2 of our cases, while edema or ascites occurred in 24 of the cases previously reported. Pain of varying degree, character, and situation was present in 4 of our cases and in 21 of the cases previously reported. Engorgement of the collateral superficial veins was found in 2 of our cases and in 11 of the cases previously reported. In only 3 of our cases was there a history of gross hematuria. In 3 other cases an occasional erythrocyte was found in the urine.

Extension of the tumorous thrombosis into the right auricle was reported in 16 of the 34 cases reported previously. This occurred in 2 of our cases. In one case (Case 1) the tumorous thrombosis extended into the right auricle and through the tricuspid valve into the right ventricle, and in the other case (Case 2) it extended into the right auricle. This was a most interesting finding and was especially striking because of the paucity of symptoms. Neither of these patients had had very severe dyspnea. The results of examination of the heart

THE ROLE OF UREA-SPLITTING ORGANISMS IN THE FORMATION OF CERTAIN TYPES OF STONES IN THE URINARY TRACT

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THE relationship of alkaline infections of the urine to the formation of certain types of stone in the urinary tract is a problem that has been of interest to investigators for many years. In 1897 Horton Smith¹ described a new variety of the proteus group, *Bacillus proteus urinae*, discovered in the urine of a patient suffering from cystitis. He pointed out that the strain he was investigating decomposed the urine, setting free ammonia and precipitating triple phosphates. In 1901 Thomas Brown,² of Baltimore, stressed the influence of certain kinds of organisms upon the composition of stones in calculous pyelonephritis. Of the six cases he presented, five had an alkaline urine, three infected with *Bacillus proteus* and two with white staphylococci. All five stones were alike chemically, being composed chiefly of the phosphates and carbonates of calcium and magnesium. In 1915 Wallace and Dudgeon,³ of St. Thomas Hospital in London, reported the case of a man, aged 60 years, who developed an infection of the urinary tract and septicemia, following suprapubic prostatectomy. The *Bacillus proteus* was cultured from both the blood stream and urine. They described the cultural characteristics of the organism but did not mention the relationship of this type of infection to possible stone formation. The case is referred to in order to emphasize isolated efforts to study urinary bacteriology more than twenty years ago.

In 1925 Shaw and Hill⁴ described another new organism, a small gram-positive bacillus, which they named the *Corynebacterium thompsoni*. It splits urea at a rapid rate and infection only occurs in wounds that are the site of urinary drainage. This organism is the most virulent of the urea-splitting group, but fortunately one that is not commonly found.

In addition to proteus and Thompson's bacilli, other organisms that have been found to decompose urea and produce an alkaline urine are certain strains of staphylococci, streptococci, pyocyanus, occasionally some strains of *B. coli*, and rarely some of the diphtheroids. *Bacillus proteus* is the organism usually found in urea-splitting infections. Out of 31 cases studied by the late Dr. Joseph Hume over a period of four years, it was present 26 times. In the other 5, staphylococci were found

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to formulate a more satisfactory plan of handling such cases. After a detailed study of 31 cases over a period of four years, he settled upon a plan which in the main involved three principles: (1) the preliminary study, with particular attention directed toward the type of infection, (2) operative treatment with special reference to drainage, and (3) a particular method of postoperative management.

In the preliminary study an immediate attempt was made to separate infected cases into (1) those associated with an acid urine and (2) those in which the organisms present decomposed urea with the production of an alkaline urine. The usual routine procedures shall be taken for granted. The reaction of the urine as determined by a pH indicator suggests the group into which the case may fall. Smears are made of the sediment from a centrifuged specimen and stained by Gram's method.

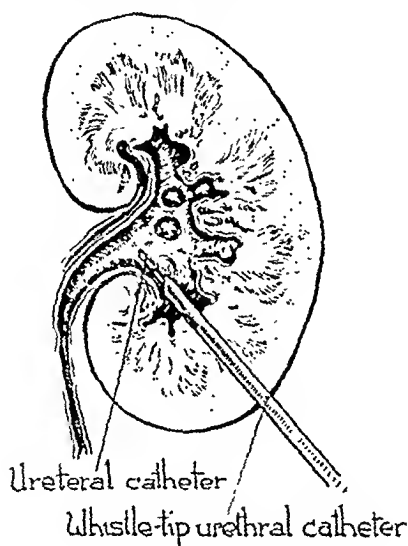


Fig. 3.—Nephrostomy tube in place after ureteral catheter has been inserted for continuous drip.

From this one determines whether the infection is coccal, bacillary, or mixed, and whether the organisms are gram-positive or gram-negative. The next step is to determine whether or not the organisms present possess the property of decomposing urea. To settle this question, Hume inoculated a tube of veal broth containing 2 per cent urea with 0.2 per cent phenolphthalein added as an indicator. The tube is placed in an incubator, kept at 37° C., and examined at intervals for the next twenty-four hours. If the organisms present decompose urea, ammonia is produced, creating an alkaline reaction and consequently a red color, due to the presence of phenolphthalein in the medium. On the other hand if the color remains amber, the organisms do not split urea. This method is simple and inexpensive in that it can be carried out in a small in-

in 2, diphtheroids in 2, and paratyphoid in 1. The importance of early recognition of this group of organisms is generally appreciated. They lead to early stone formation and produce a rapid destruction of renal tissue.

So far as the association of infection with stones is concerned, Joly³ in 1929 made his viewpoint quite clear. He stated that, if the urine is

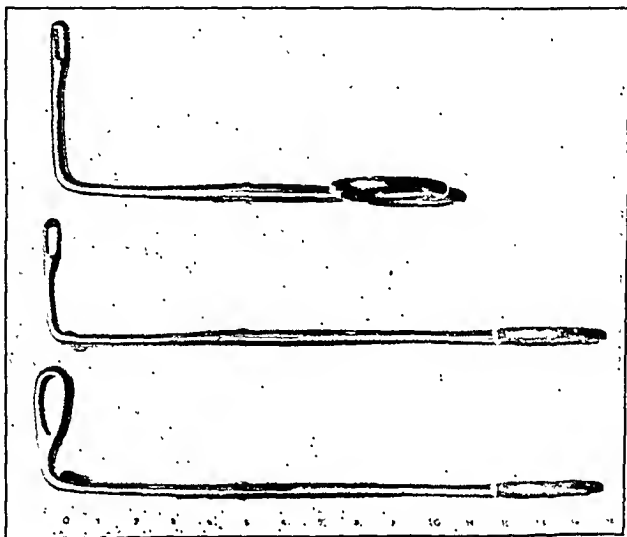


Fig. 1.—Hume stone forceps, three sizes.

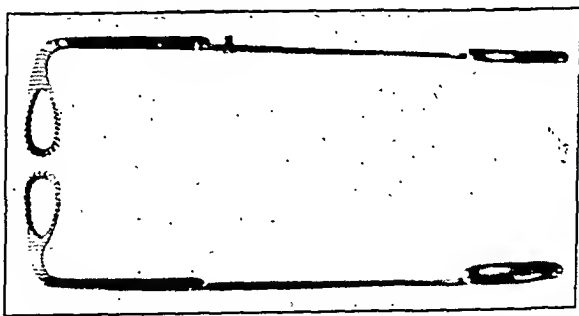


Fig. 2.—Hume stone forceps opened showing beveled corrugated edge.

acid, the stone will behave as if the urine were not infected; that is, it will grow slowly and will not as a rule have a covering of phosphates. The infection, however, will persist until after the stone is removed. On the other hand, an alkaline infection is more serious. The stone will become coated with phosphates, will grow rapidly, and will show a marked tendency to recur after removal.

Armed with all the facts presented up to that time and stimulated by an increasing number of recurrent stones, Hume, early in 1930, set about

of stone implies that the usual preliminary studies have been done, and, when one adds to that a detailed knowledge of the associated infection, the indications in treatment become quite clear.

So far as operative treatment is concerned, the aim of a well-planned attack is to remove the stone, preserve kidney tissue, combat infection, and prevent recurrence. Such operations, on the whole, demand wide exposure, gentle handling, certainty of removal of all fragments and drainage via the cortex, through the lower calyx into the pelvis. This involves chiefly the application of principles long recognized. In order to facilitate the removal of stone fragments and protect the kidney from trauma, Hume devised special stone forceps shown in Figs. 1 and 2. We have found these most useful in handling both single and multiple stones. We were able on one occasion to remove 206 small stones from

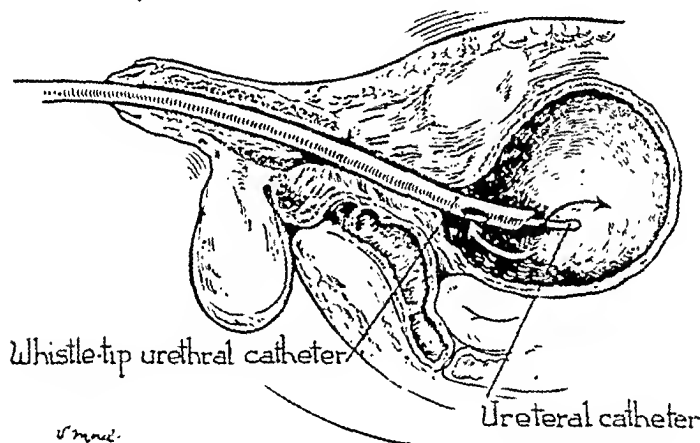


Fig. 5.—Arrangement for continuous bladder irrigation (Foley catheter may be substituted in bladder cases).

a kidney through a pelvic incision, leaving but a single fragment, which was later washed out through the nephrostomy tube. Drainage by nephrostomy tube was regarded as an essential in every case where the kidney was found to be infected with any of the urea-splitting group of organisms. It was carried out regardless of the size and number of stones removed. In addition to the beneficial action of drainage on the inflammatory lesion, it provides an opening through which small fragments may be removed and an easy means to combat infection with intermittent or continuous irrigation.

After removal of the stone, whether or not the patient is faced with recurrence is almost entirely dependent upon the efficacy of the treatment used to clear up the infection. Randall⁶ in 1932 advocated the use of phosphoric acid irrigations for this purpose. Strengths of 1 per cent, occasionally 3 per cent, were used, and the results obtained in

cubator. It enables one within twenty-four hours of the time the case is first seen to label it as being of the urea-splitting or nonurea-splitting variety. For practical purposes, this may be all that is necessary. It has been our custom, however, to identify the particular organisms present by detailed cultures in the hospital laboratory. A complete diagnosis

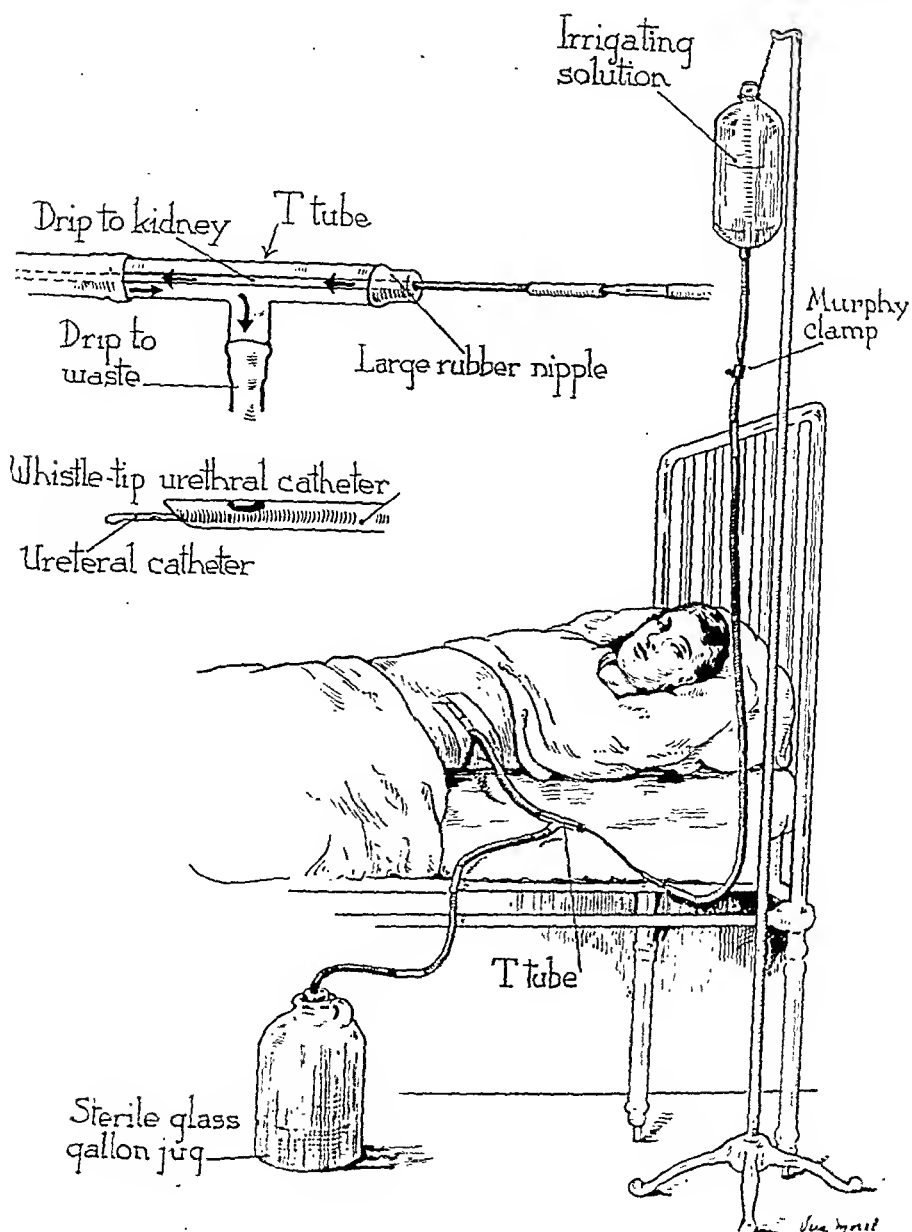


FIG. 1.—Complete set-up for giving continuous irrigation.

individual ease. If there is pain or a feeling of fullness in the kidney, the flow should be cut down. Continuous irrigation may be started by the end of the first postoperative week and continued for two or three weeks, by which time intermittent irrigations usually suffice. The intermittent irrigations are continued until the cultures are negative for urea-splitting organisms. After the patient is able to be up and about, he is taught to handle his tube and give his own irrigations.

Fragments left at operation or formed during the postoperative period present an unpleasant problem. It is impossible to clear up the infection as long as they are present, and, if allowed to remain, they soon grow to a size too large to be removed through the nephrostomy opening. Confronted with this type of problem in a case with a single kidney, and having failed to catch the fragment with various types of forceps, Hume fused the ends of No. 4 French ureteral catheters together (Fig. 6) and removed thirteen stone fragments (Fig. 7) from the pelvis of the kidney. The tips of the catheters are fused with dental wax and the bulb is made only large enough to hold them together with a firm grip. The nephrostomy tube is removed, the bulb passed into the renal pelvis, and each catheter pushed in separately for a considerable distance. After being coiled up in the pelvis, the stone fragment is almost invariably caught behind the wax bulb as the catheters are straightened out again to be removed. We have repeatedly removed fragments from the renal pelvis in this manner but have yet to catch one confined to either of the calices.

SUMMARY

An attempt is made to emphasize the relation of alkaline infections to stone formation in the urinary tract. Useful methods worked out by the late Dr. Joseph Hume are presented.

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eleven cases reported. Intermittent irrigations were given and the solution was apparently nonirritating to the urinary tract. Acting upon this suggestion, Hume in 1934 began to employ continuous irrigations by means of a two-way catheter arrangement, shown in Figs. 3, 4, and 5. He tried various solutions but agreed with Randall that by the use of

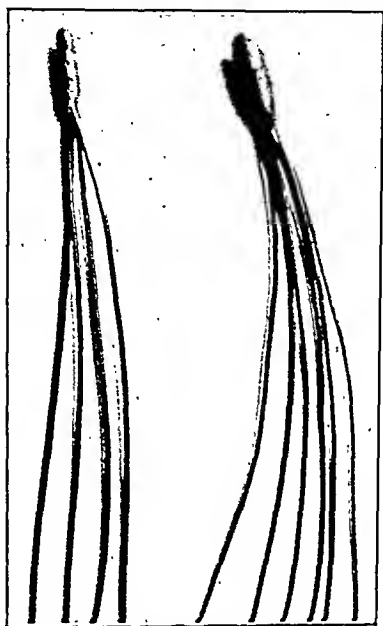


Fig. 6.—Fused ureteral catheter for removing stone fragments from renal pelvis.

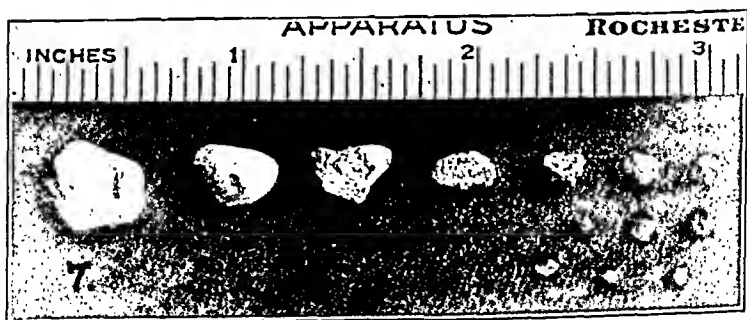


Fig. 7.—Stone fragments from a single kidney removed by catheters shown in Fig. 6.

phosphoric acid the best results were obtained. For continuous irrigation, $\frac{1}{2}$ per cent solution was used in the majority of cases. Occasionally, however, a 1 per cent strength may be tolerated. The rate of flow is controlled by a Murphy clamp placed on the tube below the infusion bottle as shown in Fig. 4. The solution is allowed to flow at a rate of 20 to 40 drops per minute, according to the tolerance of the

tenance of the vitamin B₁ stores was dependent on an adequate intake in the diet. They believe that it is possible to tell from the amount of B₁ daily excreted in the urine whether the intake of this vitamin is adequate.

There is suggestive evidence that a need for increased amounts of B₁ exists in the patient with hyperthyroidism. That this need is not satisfied in many patients with hyperthyroidism is very probable, especially if, as Sherman⁶ and Snre⁷ have stated, the average American diet is becoming more and more deficient in this vitamin. There is, moreover, clinical evidence that such a deficiency exists in many instances. Gastrointestinal symptoms are among those most commonly associated with simple B avitaminosis (Buchanan,⁸ Elsom⁹). Of these, anorexia is the most frequently encountered; a feeling of fullness in the epigastrium, gaseous eructations, constipation followed by, or alternating with, diarrhea are often associated with the anorexia. Hypo- or achlorhydria and changes in the motor function of the gastrointestinal tract are also reported by many observers in patients deficient only in the B₁ fraction (Cowgill and Gilman¹⁰ and Fitts¹¹).

Similarly, although most hyperthyroid patients have increased appetite at the onset of the disease, the majority develop anorexia as the thyrotoxic symptoms are maintained. Hinrich, Goldfarb, and Cowgill¹² have shown that anorexia develops much more rapidly in dogs fed thyroxin and a B₁ deficient diet than in those getting an adequate diet plus the same amount of thyroxin. These authors suggested, on the basis of their findings, that a B₁ deficiency may be the important factor in the anorexia and weight loss of hyperthyroid patients.

The other gastrointestinal findings previously mentioned as evidence of a B₁ deficiency are also frequently present in thyrotoxic patients. Complete achlorhydria, even after histamine, has been found in 35 per cent of a series of patients with hyperthyroidism recently studied at this hospital.¹³ Delayed gastric emptying time, a common finding in patients with B₁ avitaminosis, has also been found in many of the above-mentioned patients.

There is, therefore, evidence that a B complex, or B₁, deficiency may play a part in the production of certain of the gastrointestinal disturbances, especially the anorexia often exhibited by the hyperthyroid patient.

Considerable literature has accumulated dealing with the effect of diets deficient in vitamin B₁ or the B complex on the cardiovascular apparatus of animals and man (Weiss and Wilkins,¹ Sankaran and Krishnan,¹⁴ Jones and Snre,¹⁵ and Zell and Weiss¹⁶). Although in some species of animals bradycardia is frequently encountered, the findings most common in man are tachycardia, palpitation, dyspnea, fatigability, and a lowered exercise tolerance. Certainly no more

THE USE OF VITAMIN B₁ IN THE PREOPERATIVE PREPARATION OF THE HYPERTHYROID PATIENT

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IN NO group of surgical patients is the problem of nutrition more urgent than in the hyperthyroid patient. It has long been known that the problem is not entirely one of providing an adequate caloric intake, for even though the caloric intake, in certain instances, has been satisfactory, maintenance of weight is often not obtained. It is probable that certain accessory food factors may be deficient during the hyperthyroid state and that the deficiency may influence the clinical picture and the course of the disease. Weiss and Wilkins¹ have described the cardiac effects of a B₁ deficiency.

We have observed patients whose response to iodine therapy was highly satisfactory from the viewpoint of a reduction in the basal metabolic rate and even the pulse rate, but who continued to have anorexia and to exhibit weight loss. Other patients have maintained a tachycardia in spite of a reduction in the basal metabolic rate, while still others have lost weight out of proportion to the increase in the basal metabolic rate and the appetite level. These observations suggest that, although the food intake in total calories may be sufficient, absorption or utilization of the ingested foodstuffs may be below the normal.

That one of these factors may be the vitamin B complex, or one of its components, is suggested by the close relationship between this vitamin and thyroid function. Cowgill and his co-workers² and Hendricks³ have shown that the vitamin B complex, and especially the B₁ requirement in animals and man, bear a direct relationship to metabolism. It is said that this relationship can be expressed in a mathematical formula.² If the metabolic rate is raised by disease or the administration of thyroxin, the vitamin B₁ requirement is proportionately increased and additional B₁ must be added to the diet to prevent the appearance of the symptoms of a B₁ deficiency. That this deficiency may develop rapidly is suggested by the studies of Brodie and MacLeod,⁴ which indicate a very limited capacity for storage of vitamin B₁ in human tissues. Harris and Leong,⁵ from studies of the excretion of B₁ in the urine, concluded that the amount of this vitamin stored in the body was quite small and that the main-

tenance of the vitamin B₁ stores was dependent on an adequate intake in the diet. They believe that it is possible to tell from the amount of B₁ daily excreted in the urine whether the intake of this vitamin is adequate.

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characteristic list of the major cardiovascular symptoms associated with hyperthyroidism could be compiled. If these observations are correct, and we believe they are, they suggest that a vitamin B deficiency may intensify the changes in the cardiovascular mechanism produced by thyrotoxicosis.

The possibility that a lack of the vitamin B complex may be the initiating factor in the development of hyperthyroidism has been investigated. As early as 1914, McCarrison¹⁷ noticed hyperplasia of the thyroid gland of pigeons fed on B deficient diets. Similar findings in other experimental animals have been reported by Stepp and György,¹⁸ Spence,¹⁹ and Fischer.²⁰ Sandberg and Holly²¹ have shown that the addition of vitamin B₁ in adequate amounts to the diet of such animals will produce involution of the hyperplastic gland. Although Carpenter and Sharpless²² were unable to corroborate their findings, the possibility that this same train of events may occur in humans is suggested by a recent report in which Means, Hertz, and Lerman²³ suggest that certain cases of Graves' disease may be caused by severe degrees of malnutrition due to hopelessly inadequate diets. Certainly a vitamin B₁ deficiency must have developed rapidly in these patients, before the symptoms of thyrotoxicosis appeared.

In an attempt to put the antithyrogenic action of vitamin B₁ to a therapeutic test, Sure and his associates²⁴ studied the effect of vitamin B₁ administration upon experimentally produced hyperthyroidism. They found that by means of a highly concentrated vitamin B₁ extract they were able to reduce the injurious effect of thyroxin in the rat. Later they were able to protect these animals entirely from the toxic influences of thyroxin by the parenteral administration of crystalline vitamin B₁. The dosage of vitamin required was very large. Recently these authors²⁵ reported that, although vitamin B₁ has some antithyrogenic action, it is more effective if the other components of the B complex are added.

The role of vitamin B₁ in carbohydrate metabolism offers a clue as to the mechanism by which this substance may counteract in part the effects of thyroxin. That one of the most important functions of B₁ is the part it plays in the proper utilization of carbohydrates has been shown by Plimmer and Rosedale,²⁶ Peters,²⁷ Drill,²⁸ and Abderhalden and Wertheimer.²⁹ They²⁶ demonstrated that the administration of additional carbohydrate to the diet of various animals markedly increased their requirement for the B₁ fraction. If this requirement is not met, hyperglycemia and depletion of liver and muscle glycogen result.³⁰⁻³² If vitamin B₁ is then supplied in adequate amounts, the blood sugar falls and glycogen storage in the liver is increased.³³

It is well known that thyrotoxicosis is commonly associated with disturbances in carbohydrate metabolism. These changes are char-

acterized by hyperglycemia, decreased glucose tolerance, and depletion of liver glycogen. The similarity between these changes and those attributed to B₁ deficiency is noteworthy.

Clinicians are now agreed that one of the most important steps in the treatment of severe grades of thyrotoxicosis is to provide an abundant supply of carbohydrates in a readily assimilable form, either orally or parenterally, so that the patient may rapidly replenish his glycogen stores (Frazier and Brown,³⁴ and Lahey³⁵). The value of this form of therapy, both before and after operation, has been thoroughly established. If thyrotoxic patients are deficient in vitamin B₁, which in itself aids in the deposition of glycogen, it is equally important to supply this factor during the period that the carbohydrate intake is being increased.

From the evidence presented, it is reasonable to believe that some degree of vitamin B₁ deficiency must exist in patients with moderate or severe hyperthyroidism. A comparison of the symptomatology of the two conditions reveals certain striking similarities. That B₁ avitaminosis may contribute at least to an intensification of the thyrotoxic symptoms is a justifiable assumption. Although vitamin B₁ probably has no direct antithyrogenic action in man, the administration of adequate amounts of this vitamin should be an important factor in the treatment of severe clinical hyperthyroidism.

EXPERIMENTAL OBSERVATIONS

Several years ago we began the use of a B complex extract in patients suffering from hyperthyroidism admitted to the Hospital of the University of Pennsylvania. The patients were given large amounts of the extract with no other therapy during the period of observation. It was our impression that, although the basal metabolic rate was not reduced any more than in a control group, the general condition of the vitamin-treated patients was better than the control group. In order to evaluate the beneficial effects, if any, which were derived from the use of the vitamin, the progress of a second group of patients was compared with that of a group similarly treated in every respect except that no vitamin B was administered. The control group was composed of twenty-eight patients. The routine preoperative treatment was complete bed rest except for two hours daily; high calorie, high carbohydrate diet, 3,000 to 4,000 calories per day; saturated solution of potassium iodide, minims 5 to 10 three times a day; sodium bromide, 10 gr. three times a day, and phenobarbital, 1½ gr. nightly.

The basal metabolic rate was determined on the day following admission and at three- or four-day intervals thereafter. The patients were all weighed daily. Fifty patients composed the vitamin-treated group. In addition to the above outlined regime, these patients re-

ceived hypodermically 10 mg. of crystalline vitamin B₁² every other day, and 10 gm. of Brewers' yeast daily by mouth.

The yeast tablets administered to the first half of this group provided a daily intake of approximately 1.5 mg. of B₁ and the remainder received approximately 1.0 mg. of vitamin B₁. This means that all of the patients received between 6 and 7 mg. of vitamin B₁ daily, which is about two and one-half times their daily requirement as calculated from Cowgill's² formula.

TABLE I

| | NUMBER OF CASES | PREOPERATIVE PERIOD | | POSTOPERATIVE REACTION | |
|----------------------------|-----------------|---------------------|-------------|------------------------|-------------|
| | | PULSE DROP | B.M.R. DROP | PULSE RISE | TEMPERATURE |
| <i>Control</i> | | | | | |
| A | 14 | 19 | 39 | 34 | 102.2 |
| B | 8 | 10 | 20 | 29 | 101.6 |
| C | 6 | 6 | 8 | 22 | 101.0 |
| Total | 28 | | | | |
| <i>With B₁+</i> | | | | | |
| A | 28 | 26 | 38 | 38 | 101.8 |
| B | 13 | 16 | 14 | 33 | 101.6 |
| C | 9 | 8 | 15 | 38 | 101.0 |
| Total | 50 | | | | |

Each series was divided into three groups, Group A being those whose basal metabolic rate on admission was over 40; Group B, between 30 and 40; and Group C, those between 20 and 30. The various criteria of comparison are outlined in Tables I and II. It will be seen that only those patients whose admission metabolic rates are within the same range are compared (Tables I and II).

TABLE II

| | NUMBER OF CASES | PREOPERATIVE HOSPITAL DAYS | AVERAGE WEIGHT CHANGE (POUNDS) | GAINED WEIGHT (POUNDS) | LOST WEIGHT (POUNDS) | NO CHANGE | APPETITE | |
|----------------------------|-----------------|----------------------------|--------------------------------|------------------------|----------------------|-----------|---------------------|-------------------|
| | | | | | | | GOOD | FAIR TO POOR |
| <i>Control</i> | | | | | | | | |
| A | 14 | 15 | -1.2 | | | | 16 cases | 12 cases |
| B | 8 | 9.5 | -0.6 | | | | 31.2% gained weight | 25% gained weight |
| C | 6 | 7 | 0.0 | | | | | 25% improved |
| Total | 28 | 11.1 | -0.4 | 2.8 (23.5%) | 3.0 (46.5%) | 25.0% | | |
| <i>With B₁+</i> | | | | | | | | |
| A | 28 | 12 | +1.6 | | | | 37 cases | 13 cases |
| B | 13 | 9 | +2.1 | | | | 81% gained weight | 85% gained weight |
| C | 9 | 7 | +1.7 | | | | | 50% improved |
| Total | 50 | 9.1 | +1.8 | 3.0 (72.0%) | 3.5 (20.0%) | (8.0%) | | |

*Kindly supplied by Merck and Co., Rahway, N. J.

A study of our data brings out several interesting points. There are three respects in which the vitamin-treated group show improvement over the control series; namely, the degree of the reduction in pulse rate during the period of preparation, the number of patients who gained weight and whose appetite increased, and the length of time required for adequate preoperative preparation.

These findings are in agreement with the known effect of vitamin B₁ on the cardiovascular and gastrointestinal systems, if some degree of B deficiency exists. That vitamin B₁ or the B complex has no direct antithyrogenic action in man is shown by the fact that the two series showed no significant differences in the lowering of the basal metabolic rate before operation, nor in the severity of the postoperative reaction.

A point worth emphasizing is the fact that where improvement was noted in the vitamin-treated series it was most marked in the more toxic group. These are the patients in whom an avitaminosis is most apt to develop, and who in consequence should be most benefited by vitamin therapy. The milder cases of hyperthyroidism may not have developed any vitamin deficiency and it is well known that vitamin B₁ produces no effect on the normal gastrointestinal tract and normal cardiovascular system.

SUMMARY

It is our opinion that the severely thyrotoxic patients have been benefited by the administration of vitamin B₁. Not only is the nutritional state improved, as evidenced by increased appetite and weight gain, but also patients with severe hyperthyroidism can be adequately prepared for operation in a shorter time. That the vitamin treated cases showed a greater fall in heart rate during the preparatory period suggests that the tachycardia may have been due, in part, to a vitamin B deficiency and, therefore, was improved by the administration of adequate amounts of this vitamin.

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NONOPERATIVE TREATMENT OF PERFORATED GASTRIC ULCER WITH GENERALIZED PERITONITIS BY CONTINUOUS GASTRIC SIPHONAGE

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THE thesis of this comment is that surgery and surgeons not only "must" but "will," in the natural development of things, broaden their field of action to encompass all technical processes and new developments that come into immediate relation with surgical problems. In this perspective this paper affirms that the surgeon is today, in the course of his natural development, taking into his armamentarium a more comprehensive knowledge and use of such recent innovations as: (1) the Wangensteen nasal suction siphonage technique in the non-surgical management of general peritonitis arising from ruptured appendix, perforated peptic ulcers, and bowel perforations and in post-operative peritonitis; (2) vitamin therapy for the deficiency diseases developing postoperatively in cases having a long convalescence and relative or absolute functional intestinal incompetency; (3) possible future hormonal, humoral, and chemical perspectives on and management of certain types of malignancies, hypertension, vascular spasms, and autonomic nervous system dysfunctions. In another way of saying it, surgery and surgeons, in their natural development, will acquire an insight into and a facility with related endocrine, chemical, physiologic, and physical data, as these features are established in more and more immediate relation to the so-called strictly surgical problem. The surgical ability and judgment necessary to the decision to operate connotes equal ability and facility to not operate and to manage non-operatively.

CASE REPORT

White male, aged 33 years, farmer, was admitted to University Hospital, Oklahoma City, Nov. 3, 1937, complaining of pain in stomach, nausea and vomiting, and bloating. History of attacks of dull, burning, epigastric pain, coming on three or four hours after eating, often referred to the chest area. Attacks lasted from a few days to two or three weeks, with pain-free periods of from one month to one year. The pain was usually relieved by taking food and also by taking sodium bicarbonate, although this usually caused vomiting and for that reason was rarely taken. Patient stated that he was often compelled to leave his work to obtain food which seemed to "expand" his stomach and relieve the pain. This pain seemed to be increased by exertion, excitement, or jarring. History of severe attack about two years ago which subsided after about two weeks. Present attack

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began about three weeks prior to admission to the hospital, characterized by almost continuous right subcostal and epigastric cramping, malaise, and some diarrhea. The pain during this attack was aggravated by taking food of any kind. There was some relief obtained by taking sodium bicarbonate, which was followed by vomiting. On the evening of Nov. 1, 1937, two days before admission, patient was stricken with a sudden sharp excruciating pain in the epigastrium and right subcostal area which was so severe that he was unable to lie down. Sodium bicarbonate was taken with no relief. Epsom salts also gave no relief. Morphine was finally administered by local physician with some relief.

On admission to hospital, examination revealed a dehydrated, emaciated, and apparently extremely ill patient. Temperature, 100.8°; pulse, 120; respiration, 24. Lips dry and cracked. Tongue very dry and covered with heavy dry mucus. Chest

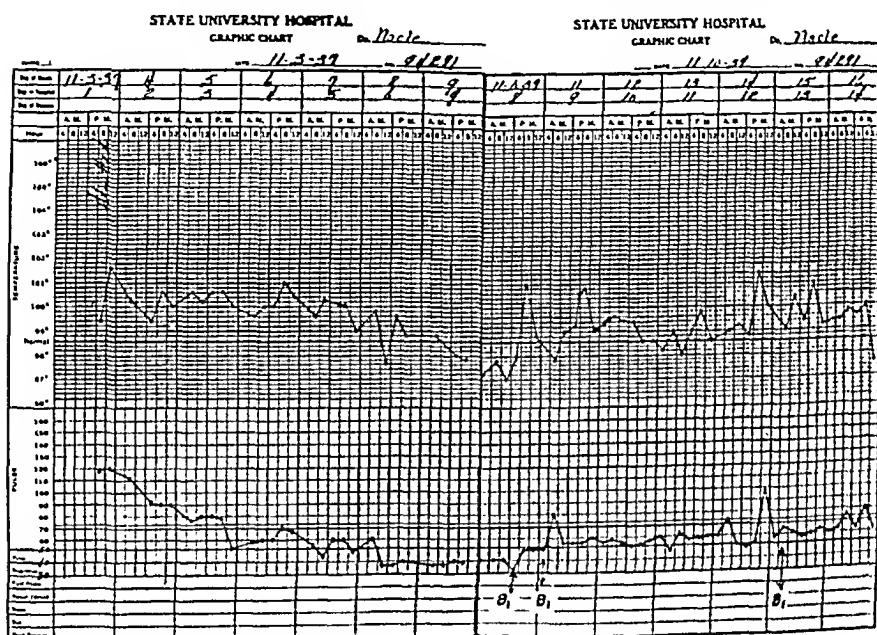


Fig. 1.—Shows a drop in pulse rate to a normal of 80 on the fifth day and a pronounced bradycardia of 36 to 10 beats per minute, beginning on the eighth day of illness.

and heart negative. There was uniform distention, shifting dullness, and flatness in each flank. Abdomen quiet, tympanitic in midportion and in suprahepatic area, with resonance above and flatness of liver below. Rebound and palpation tenderness generalized, more marked in right upper quadrant. *Laboratory:* Urine negative. Blood: Hemoglobin 15 gm. RBC 4,150,000; WBC 5,150, with 80 per cent neutrophils. Widal, negative. Stools negative for typhoid. X-ray: Interpreted as "free air in abdominal cavity, some of which is separating liver from right diaphragm. Multiple fluid levels throughout. Small intestine loops are considerably dilated." Fluoroscopic examination sixteen days later showed "stomach considerably distended by gas, deep large peristaltic waves, barium empties readily into duodenum; upper intestinal loops are moderately dilated. Large niche in the lesser curvature at the pylorus. Duodenal cap is normal. Stomach is empty in two hours. At six hours, terminal ileum is filled. X-ray findings are consistent with pyloric ulcer without



Fig. 2.—Reveals gas under both diaphragms, fluid levels in the stomach and many loops of the intestine, distention of the bowel with "fluid mirrors," "separation effect" of intraperitoneal fluid. This x-ray is definitely characteristic of perforated hollow viscus.



Fig. 3.—Shows x-ray after complete recovery, defining presence of large pyloric ulcer.

mechanical obstruction and residual paralytic ileus." *Diagnosis:* (1) Perforated peptic ulcer of forty-eight hours' duration with generalized peritonitis and intestinal ileus; (2) bradycardia, diastolic murmur, palpable at radial artery, which is not due to typhoid fever; (3) inanition with vitamin B₁ deficiency; (4) proved pyloric ulcer.

Management: Institution of management recommended by Waugensteen; namely, continuous nasal suction siphonage for gastric and intestinal decompression, parenteral fluids, interdiction of everything by mouth. Dramatic clinical improvement in forty-eight hours; abdomen generally soft, distention markedly reduced, hippocratic facies had disappeared, pulse and temperature reduced. Bradycardia of 36 manifested itself on the sixth day; was definite and sustained for two days thereafter, until the first administration of vitamin B₁. Patient was sustained for the first two weeks entirely by parenteral fluids, saline, glucose, Hartman's solutions. Synthetic vitamin B₁ in doses of 2,000 international units was given hypodermically. Surgical closure of perforation was not attempted and it was not necessary to drain residual abscesses. Subsequent convalescence uneventful.

COMMENT

It is to be noted in the history that for three weeks prior to admission to the hospital the patient had been taking soda for the relief of epigastric pain, had been vomiting, and had been unable to retain a normal diet. Nothing was given by mouth for the first fourteen days in the hospital. Nasal siphon was in continuous use for the first ten days in the hospital. It is believed by the writer that this further depleted the patient of all vitamin B₁ reserve and precipitated the bradycardia noted Nov. 8, 1937. This position is seemingly well taken, in the light of the remarkable and immediate remedial effect noted with each administration of synthetic vitamin B₁ hypodermically. Another effect of the vitamin B₁ is possibly the improved sedimentation rate. The writer evaluates this change in sedimentation time as an improvement in the vitality of the patient. In this relation a tenable hypothesis is that the sedimentation time is a function of the "charge" on the surface of the red blood cells, which, if reduced, permits a rapid falling out of suspension of the red blood cells and which, if "normal" or increased, holds the cells in separation and hence in suspension.

Early surgical closure of the perforation of the stomach and duodenum is always in order and surgical closure must be free from leakage. This is aided materially by maintaining continuous evacuation of the stomach and duodenum with suction siphonage. A point this paper wishes to emphasize is that it is not the hole in the stomach per se, but the leakage through the hole in the stomach that causes and maintains the fatal peritonitis in these cases and that even in cases that seem too late for surgical closure of the perforation the prognosis is materially improved by maintaining a continuously empty stomach and duodenum. This may be effected only by the continuous nasal suction siphonage.

The popularization of the nasal suction siphon decompression of the upper reaches of the intestinal tract will probably stand out in future

years as the event signalling a reorientation in surgical thinking to a more physiologic and more dynamic pattern than previously. Proficient technicians will always be appreciated, but surely in the coming years, if surgery is to be advanced, more stress and emphasis must be placed upon its physiologic aspects. The surgery of tomorrow will be defined by minds that are challenged by a problem and that do not abate their efforts until a practical solution is uncovered. In the same perspective it appears certain that medical knowledge is advanced more by the elaborate and painstaking study of individual case problems than by statistical reviews.

CONCLUSION

The instance of a patient with acute perforation of forty hours' standing of a gastric ulcer into the free peritoneal cavity successfully treated without operation by continuous suction applied to an indwelling duodenal tube is reported. The early closure of all perforations of the gastrointestinal canal by open operation is insisted upon. The great value of decompression by gastric and intestinal siphonage in late cases is discussed.

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ACIDITY OF GASTRIC CONTENTS AFTER EXCISION OF THE ANTRAL MUCOSA*

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INCONTROVERTIBLE proof that the antral mucosa is of physiologic importance in the maintenance of the intragastric or chemical phase of gastric secretion has not as yet been presented. The suggestion that when food comes into contact with the antral mucosa the fundic mucosa is stimulated to secrete acid is an interesting but unproved hypothesis.

Interest in the physiology of the intragastric phase of gastric secretion was stimulated by the work of Edkins in 1906. He found that an extract of the antral mucosa contained an active substance, which, when injected intravenously into dogs, stimulated secretion of gastric juice. The results of subsequent investigations would indicate that histamine was the active principle in the extracts employed by Edkins.

Since Edkins' work there has been a more or less fruitless search for some hormonal substance which is contained in or liberated by the antral mucosa and which stimulates gastric secretion. Many active extracts have been prepared, yet the subject of hormonal stimulation of gastric secretion is still confused. Nevertheless, a true gastric secretion may exist.

The somewhat less complicated problem of whether or not the antral mucosa affects secretion in the fundus sufficiently to be physiologically important has been extensively studied. In one experimental approach food is placed in an isolated antral pouch, and fundic secretion is analyzed for acid. Edkins and Tweedy, Lim, Ivy, and McCarthy, Johnson, Babkin, and Sawitsch and Zelony found acid secretion in the fundus. Priestley and Mann did not find satisfactory evidence that food in an antral pouch stimulated acid secretion in the fundus.

In another approach to the problem, whole stomach pouches were prepared, some with and some without the antrum of the stomach. Analysis of the gastric contents was then done in the usual fashion. Kim, Babkin, and Wilhelmj, O'Brien, and Hill obtained decreased acid secretion in those whole stomach pouches from which the antral portion had been removed.

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A third method of study involves resection of the antrum and performance of gastroenterostomy in the same way that partial gastrectomy is performed on the human being. With test meals, Smidt, Babkin, Wilhelmj, O'Brien and Hill, and Klein found reduction in acid secretion after resection of the antrum. Portis and Portis, Steinberg, Brougher and Vidgoff, Priestley and Mann, Fauley, Strauss, and Ivy, and Shapiro and Berg obtained either inconclusive evidence of reduction in acidity, or only temporary hypoacidity.

Gastroenterostomy permits more regurgitation of intestinal contents than is found in the normal stomach. In all of the experimental methods mentioned, the muscular and probably the nervous continuity of the

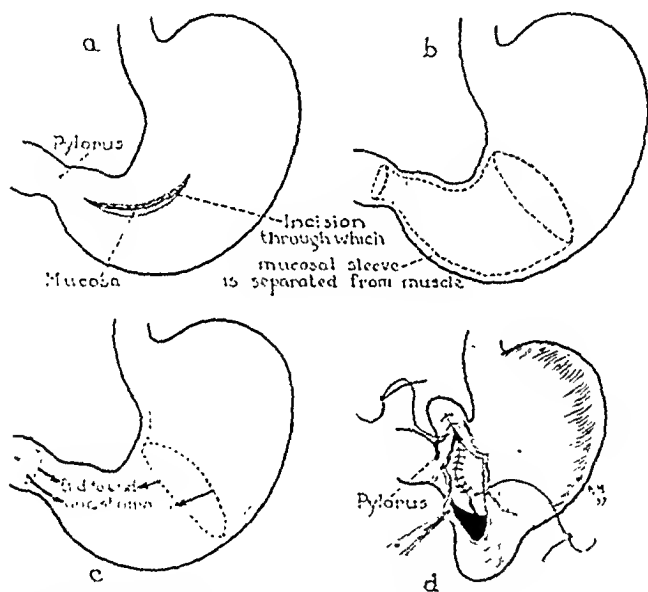


Fig. 1.—Diagrammatic representation of steps in the operation for the removal of the antral mucosa: a, longitudinal incision extending down to mucosa; b, sleeve of mucosa that is excised; c, end-to-end anastomosis; d, completion of anastomosis.

stomach and the intestine is interrupted. As both of these factors make experimental results difficult to interpret, an attempt was made in this study to excise the antral mucosa without causing excessive regurgitation of intestinal fluid and with as little interruption of gastrointestinal continuity as possible.

METHOD

Operation.—A longitudinal incision 6 to 8 cm. long was made on the anterior surface of the distal portion of the stomach. This incision terminated 2 cm. proximal to the pyloric muscle and extended down to the mucosa. By blunt dissection the mucosa was separated from the muscularis distally into the first centimeter of the duodenum and

proximally till the increase in fibrous attachment to the muscularis indicated that fundic mucosa had been reached. The cuff of antral mucosa thus freed from the muscularis was excised and the edge of fundic mucosa was anastomosed to the edge of the duodenal mucosa. The longitudinal incision in the muscularis was closed transversely in order to prevent tension on the mucosa (Fig. 1). By this procedure the pyloric mucosa is removed; the pyloric muscle remains intact and in control of the outlet of the stomach, and only mucosal continuity is interrupted.

To determine the effect of the operation on the emptying time of the stomach, roentgenoscopic studies with a standard (throughout the study) barium meal were made before and after operation.

As the trauma of operation is said to diminish acid secretion for a time, analyses of gastric contents were done, with subcutaneous injection of histamine as the stimulus, before and after operation.

A standard (throughout the study) ground meat and water test meal was used to determine the secretory response to food in the presence of and in the absence of the antral mucosa. Analyses of the gastric contents with histamine and with the meat meal were made one to four months after operation, and analyses with the meat meal were repeated eight to eleven months after operation.

Ten to twelve months after operation the dogs were killed; the stomachs were examined grossly and specimens of tissue were cut from two places in the mucosal suture line in each stomach for histologic study of the mucosa on each side of the anastomosis.

RESULTS

Within one month after the operation, the animals were well nourished and in good condition. The emptying time of the stomach of different animals varied between four and seven hours before operation. One to three months after operation the emptying time varied between four and eight hours. Therefore, the gastric emptying time after operation was considered to be within the limits of normal variation.

Analyses of the gastric contents after stimulation with histamine revealed little significant change in acidity curves after resection of the antral mucosa (Fig. 2 and Table I). Hence the capacity of the fundic mucosa to secrete acid after strong stimulation apparently was not affected by the operation.

Curves of acidity of the gastric contents obtained by analysis after administration of the meat meal were much lower than the normal acidity curves in four dogs one to four months after operation (Fig. 3 and Tables II and III). In two dogs these acidity curves were only

a little lower than the normal acidity curves determined before operation (Fig. 4 and Tables II and III). Eight to eleven months after operation the dogs that had a much lower acidity after operation than they did before showed some slight additional lowering of acidity. One of the dogs that had but little lowering of acidity of the gastric contents im-

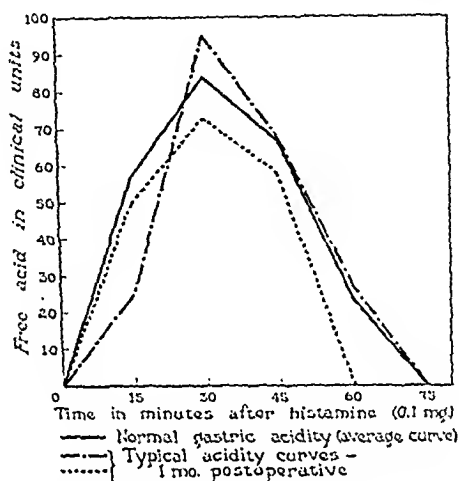


Fig. 2.—Results of analyses of gastric contents after injection of histamine (Dog 1).

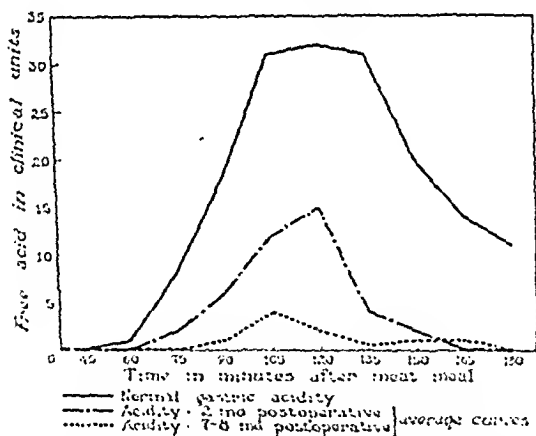


Fig. 3.—Results of analyses of gastric contents after administration of meat test meal and total excision of antral mucosa (Dog 1).

mediately after operation also showed a little additional lowering of the acidity in eight to eleven months after operation.

On gross examination of the stomachs immediately after the dogs were killed, the mucosa appeared to be normal and the pyloric outlet appeared to be of normal size and contractibility. Sections prepared from the tissue at the mucosal anastomosis were examined microscopically. Fundic mucosa was found adjacent to duodenal mucosa in the stomachs

TABLE I

ANALYSES OF GASTRIC CONTENTS AFTER ADMINISTRATION OF HISTAMINE (Dog 1)

| MINUTES AFTER ADMINISTRATION OF HISTAMINE | 0 | 15 | 30 | 45 | 60 | 75 |
|--|---|----|----|----|----|----|
| Average titration figures (clinical units) in normal dog | 0 | 57 | 84 | 67 | 24 | 0 |
| Titration figures in same dog 1 month after resection of antral mucosa | 0 | 25 | 95 | 68 | 27 | 0 |
| Two typical curves | 0 | 50 | 73 | 58 | 0 | 0 |

of the four dogs with marked lowering of gastric acidity after operation (Fig. 5). A very small amount of antral mucosa was found on the gastric side of the mucosal anastomosis in the two dogs with only slight reduction of acidity after operation.

TABLE II

SUMMARY OF ANALYSES OF GASTRIC CONTENTS AFTER MEAT MEALS

| DOG | DESCRIPTION | NORMAL | | | 1 TO 3 MO. AFTER RESECTION | | | 7 TO 11 MO. AFTER RESECTION | | |
|-----|-------------------------------------|--------------------|--|---|----------------------------|--|---|-----------------------------|--|---|
| | | NUMBER OF ANALYSES | RANGE OF MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) | AVERAGE MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) | NUMBER OF ANALYSES | RANGE OF MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) | AVERAGE MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) | NUMBER OF ANALYSES | RANGE OF MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) | AVERAGE MAXIMAL VALUE FOR FREE ACIDITY (CLINICAL UNITS) |
| 1 | Total resection of antral mucosa | 15 | 60 to 15 | 32 | 16 | 37 to 10 | 15 | 14 | 20 to 0 | 4 |
| 2 | Total resection of antral mucosa | 12 | 90 to 42 | 46 | 15 | 57 to 0 | 18 | 13 | 35 to 0 | 11 |
| 3 | Total resection of antral mucosa | 12 | 65 to 27 | 30 | 17 | 45 to 0 | 16 | 14 | 25 to 0 | 7 |
| 4 | Total resection of antral mucosa | 18 | 60 to 25 | 31 | 17 | 45 to 0 | 9 | | | |
| 5 | Subtotal resection of antral mucosa | 16 | 63 to 30 | 40 | 16 | 90 to 45 | 46 | | | |
| 6 | Subtotal resection of antral mucosa | 16 | 63 to 32 | 38 | 14 | 48 to 20 | 29 | 14 | 45 to 10 | 15 |

COMMENT

Although direct proof is lacking, it seems logical to infer that in the absence of abnormal coloration of gastric contents by bile, with a normal gastric emptying time, with the pyloric outlet of normal size, and with the pyloric muscle intact, regurgitation of intestinal contents would not be increased very much if at all after operation. A normal acidity of the gastric contents after stimulation with histamine also is some indication that intestinal contents did not neutralize and dilute gastric secretion to an abnormal degree after operation.

If the trauma of operation diminished the capacity of the fundie mucosa to secrete hydrochloric acid, one would expect lowering of the acidity of the gastric contents following stimulation with histamine as well as after a meat test meal. However, the acidity of the gastric con-

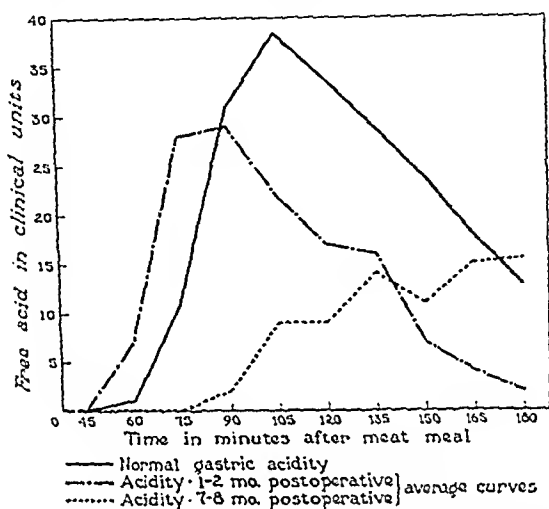


Fig. 4.—Results of analyses of gastric contents after administration of meat test meal and subtotal excision of antral mucosa (Dog 6).



Fig. 5.—Section from mucosal anastomosis; antral whose acidity curves are shown in Fig. 3; fundal mucosa may be seen on the right and duodenal mucosa on the left (Dog 1).

tents following stimulation with histamine was not lowered after operation. Therefore, dilution and neutralization of gastric secretion by excessive quantities of intestinal secretion, and the trauma of the operative procedure, cannot well account for the hypoacidity, with a meat test meal, that was present after removal of the antral mucosa. Yet in some manner the normal stimulus to acid secretion that is usually associated

TABLE III

ANALYSIS OF GASTRIC CONTENTS AFTER ADMINISTRATION OF MEAT MEAL; AVERAGE TITRATION FIGURES EXPRESSED AS CLINICAL UNITS

| TIME IN MINUTES AFTER ADMINISTRATION OF MEAT MEAL | | 0 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 165 | 180 |
|--|---|---|----|----|----|----|-----|-----|-----|-----|-----|-----|
| Dog 1 (see Fig. 3 and Table II) total resection of antral mucosa | Normal dog | 0 | 0 | 1 | 8 | 18 | 31 | 32 | 31 | 20 | 14 | 11 |
| | 1 to 2 mo. after resection of antral mucosa | 0 | 0 | 0 | 2 | 6 | 12 | 15 | 4 | 2 | 0 | 0 |
| | 7 to 8 mo. after resection of antral mucosa | 0 | 0 | 0 | 0 | 1 | 4 | 2 | 0.5 | 1 | 1 | 0 |
| | | 0 | 0 | 1 | 11 | 31 | 38 | 34 | 29 | 24 | 18 | 13 |
| Dog 6 (see Fig. 4 and Table II) sub-total resection of antral mucosa | Normal dog | 0 | 0 | 1 | 11 | 31 | 38 | 34 | 29 | 24 | 18 | 13 |
| | 1 to 2 mo. after resection of antral mucosa | 0 | 0 | 7 | 28 | 29 | 22 | 17 | 16 | 7 | 4 | 2 |
| | 7 to 8 mo. after resection of antral mucosa | 0 | 0 | 0 | 0 | 2 | 9 | 9 | 14 | 11 | 15 | 15 |
| | | 0 | 0 | 0 | 0 | 2 | 9 | 9 | 14 | 11 | 15 | 15 |

with the presence of food in the stomach was appreciably diminished after the removal of the antral mucosa. The same operation was performed on two dogs, except that a very small portion of the antral mucosa was left accidentally in the stomach. Marked hypoauidity did not occur in these two animals.

A cursory examination of the results of these experiments would appear to indicate that the loss of the antral mucosa, with the stomach otherwise intact, impairs the normal intragastric stimulation of acid secretion and that these results are due to an absence of a hormone produced in the pyloric mucosa. However, two considerations of the data seriously invalidate the conclusions that the existence of a pyloric hormone has been proved by these experiments. It does not appear probable that the small amount of pyloric mucosal remnant which was certainly less than 1 per cent of the total amount of antral mucosa, left in two of the animals, was the cause of a hypoauidity's not developing on the basis that this small amount of mucosa produced an adequate amount of hormone. A serious objection for accepting these results as proof that a pyloric hormone exists is the fact that the hypoauidity developed progressively and was greater eleven months after operation than it was at the end of the first month. It should be noted that, according to the results of the histamine test, the secretory tone of the fundic mucosa was maintained throughout the period of observation.

As the number of animals used in this study is small, definite conclusions are not justified. Yet the close similarity of the results in different animals suggests that these observations may be of some physiologic significance. More extensive study of a larger group of animals would be necessary to avoid some of the possible sources of

error in these studies and to give more statistical significance to the experimental results. Different types of test meals also should be employed as the ideal test meal has not as yet been devised for this type of investigation.

SUMMARY

Total excision of the antral mucosa was accomplished without interrupting the muscular and, in all probability, the nervous continuity of the gastrointestinal tract, and without obvious increase in regurgitation of intestinal contents into the stomach. Complete excision of the antral mucosa did not change the secretory response to the histamine test, but was followed by marked hypoacidity, as determined by a meat test meal. Further investigation is necessary before the results obtained can be ascribed to the absence of a pyloric hormone. However, the method used does offer possibilities of proving whether or not such a hormone exists.

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WANDERING SPLEEN WITH TORSION OF THE PEDICLE

A PATIENT TREATED BY SPLENECTOMY WITH ALARMING EVENTS DURING CONVALESCENCE

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WANDERING spleen with torsion of the pedicle is of relatively infrequent occurrence. Abell¹ collected 95 case reports and added 2 cases of his own to this series. Of this number only 1 patient was under 10 years of age, a male child 6 years old, operated upon by Southam,² of England, in 1921. This boy was seized with a sudden, sharp pain in the right iliac fossa and was thought to have an acutely inflamed appendix. Laparotomy revealed a large, congested spleen in the right iliac fossa twisted two and one-half times on an elongated pedicle. Splenectomy was done and the boy was discharged recovered nineteen days after operation.

In August, 1934, Percy³ reported a similar case in a boy 10 years old. Motley⁴ added a third case in a boy 8 years of age. These children also recovered after splenectomy. These are the only case reports we have been able to find in which the patients were under 10 years of age.

Because of the rare opportunity to study this condition in a child, the following case from our records is reported.

CASE REPORT.—No. 40774. F. D., a white female child, aged 8 years, was admitted to the hospital Nov. 23, 1937 at four o'clock in the afternoon. Her mother stated that she had always been well. In early childhood she had measles and chicken pox but no serious illnesses or operations. Her bowels had always been sluggish. For a week before admission she had an upper respiratory infection with mildly productive cough. Two days before entry she complained of pain in the region of the umbilicus associated with nausea and vomiting. Twenty-four hours later the pain became localized in the right lower quadrant. Anorexia, nausea, and vomiting persisted. The severity of the pain increased and spread throughout the entire abdomen. She was seen by Dr. John McNamara, of Taunton. Upon his first examination he found the mass centrally located in the lower abdomen. From its smooth surface, its firm texture and mobility, he suspected a cyst of pelvic origin. Then he felt an indentation on one border which at that examination suggested the spleen. At a later hour, however, the mass had shifted to the right iliac fossa. Finally, believing it to be an appendiceal abscess involving the omentum, he sent the patient to the hospital.

On admission the child's temperature was 101.4°, her pulse 120, and respirations 24. She looked moderately ill, and coughed frequently as a result of the upper respiratory infection. The lungs were clear and resonant. The heart was normal. No murmurs were heard. There was a mass in the right lower abdomen, smooth,

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dense, movable, and tender. The impression of the examiner was that of either an omental abscess of appendiceal origin or an ovarian cyst with twisted pedicle. At this time the white count was 24,000.

Laparotomy was performed eight hours after admission. Upon opening the peritoneum, serosanguineous fluid escaped. A large, bluish-black mass occupied the right lower quadrant of the abdomen. This was identified as the spleen several times its normal size. It was not adherent and was readily delivered through an enlarged incision. The pedicle was about $2\frac{1}{2}$ cm. in diameter, and was twisted three times clockwise on its axis. The veins were thrombosed. The pedicle was clamped, ligated,



Fig. 1.—The spleen.

and the spleen was removed. The appendix was normal and was left in situ. There was no evidence of thrombosis of the mesentery.

The appearance of the spleen is seen in Fig. 1. It weighed 425 gm. as compared with 110 gm., the average normal weight of the spleen in a child 8 years of age. Except for its enlargement, it was normal in configuration. The capsule was smooth and darker than normal in color. The pedicle was cordlike instead of the usual membranous type. Cut section revealed a firm pulp, dark maroon in color, with numerous hemorrhagic areas. Microscopic examination showed tremendous engorgement of the pulp with areas of infarction. The Malpighian corpuscles were not readily discernible. The diagnosis was strangulation of the spleen due to torsion of the pedicle.

After operation the patient coughed frequently, raising small amounts of white mucus. She vomited at intervals almost all fluids taken. Acetone was present in a specimen of urine. The CO_2 combining power was not determined because of a defective apparatus. Therefore, to combat acidosis, parenteral fluids were administered. No inflammatory changes in the wound were noted.

X-ray examination of the chest Nov. 29 showed no evidence of lung pathology.

For a week after operation her condition remained about the same. At 4:00 A.M. on Nov. 30, after an attack of coughing, several feet of small intestine eviscerated through the incision. Under chloroform anesthesia the intestine was replaced and the wound closed with through-and-through sutures of silk-worm gut. A transfusion of 300 c.c. of citrated blood was given and gastric drainage employed. The patient improved rapidly after this intervention. She retained all fluids and bowel function was restored.

Blood studies carried out during convalescence showed the following:

| | ERYTHRO- CYTES | LEUCO- CYTES | HEMO- GLOBIN | NEUTRO- PHILES | LYMPHO- CYTES | LARGE MONO- NUCLEARS | EOSIN- OPHILES |
|---------|-------------------|-----------------|-----------------|-------------------|------------------|----------------------------|-------------------|
| Nov. 23 | | 24,000 | | | | | |
| Nov. 24 | 4,490,000 | 24,800 | 80% | 82% | 8% | 10% | |
| Nov. 25 | | 22,400 | | | | | |
| Nov. 26 | 3,990,000 | 11,900 | 72% | 61% | 32% | 5% | 2% |
| Nov. 27 | | 15,100 | | | | | |
| Nov. 29 | | 28,700 | | | | | |
| Nov. 30 | 3,540,000 | | 65% | 81% | 16% | 3% | |
| Dec. 1 | | 24,600 | | | | | |
| Dec. 3 | | 11,900 | | | | | |
| Dec. 8 | 3,690,000 | 7,800 | | | | | |
| Dec. 9 | | 7,700 | | | | | |
| Dec. 10 | 3,780,000 | 8,900 | | | | | |
| Dec. 11 | | 8,800 | | | | | |
| Dec. 13 | 3,870,000 | 8,200 | | | | | |
| Dec. 14 | | 8,900 | | | | | |
| Dec. 15 | 3,850,000 | 9,300 | | | | | |
| Dec. 16 | | 9,100 | | | | | |
| Dec. 17 | 4,250,000 | 7,500 | | | | | |
| Dec. 18 | | 6,200 | | | | | |

The number of blood platelets rose from 180,000 to 270,000 from Dec. 3 to Dec. 18. Two analyses of the smear showed anisocytosis and some polychromasia. The blood Kahn test was negative. The bleeding time was 1 to 1½ minutes.

The blood sugar was 105 mg.; the nonprotein nitrogen following the first operation was 30 mg. On the day before evisceration occurred, it rose to 49.8 mg.

Analysis of seven specimens of urine was negative for acetone.

This patient was discharged recovered Dec. 19, 1937, twenty-six days after admission. She felt very well for five days. Then on Dec. 24 she began to complain of sharp, colicky pain in the left upper quadrant of the abdomen. During the day she vomited frequently and had complete obstipation. Since her condition did not improve, she was readmitted to the hospital.

There it was found that the abdomen was distended and tympanitic. There was tenderness to the left of the umbilicus. Peristalsis was visible and borborygmus marked. Examination of the urine was negative. The blood picture was the same as that of the preceding week: 77 per cent hemoglobin; 3,810,000 erythrocytes; 7,900 leucocytes; 61 per cent neutrophiles; 32 per cent lymphocytes; 5 per cent large mononucleurs; 1 per cent eosinophiles; and 1 per cent basophiles. The impression of the examiner was acute intestinal obstruction.

The abdomen was reopened. A loop of small bowel about 35 cm. in length, purplish in color, was found obstructed by a dense fibrous band. This was severed and immediately the color of the affected bowel improved. The abdomen was then closed.

This convalescence was uneventful. Examination of the blood showed the following:

| | ERYTHRO- CYTES | LEUCO- CYTES | HEMO- GLOBIN | NEUTRO- PHILES | LYMPHO- CYTES | LARGE MONO- NUCLEARS | EOSINO- PHILES | BASO- PHILES |
|---------|-------------------|-----------------|-----------------|-------------------|------------------|----------------------------|-------------------|-----------------|
| Dec. 28 | 3,810,000 | 7,900 | 77% | 61% | 32% | 5% | 1% | 1% |
| Dec. 31 | 3,980,000 | 8,000 | 80% | 56% | 34% | 8% | 2% | |
| Jan. 3 | 3,760,000 | 6,700 | 77% | 54% | 39% | 3% | 3% | 1% |
| Jan. 6 | 4,100,000 | 9,700 | 78% | 42% | 52% | 5% | 1% | |
| Jan. 10 | 3,990,000 | 11,800 | 79% | 35% | 61% | 3% | 1% | |
| Jan. 12 | | 8,800 | | | | | | |
| Jan. 13 | 3,990,000 | 8,700 | 80% | 28% | 68% | 4% | | |

The blood platelet count ranged from 230,000 to 270,000. In two specimens there was slight anisocytosis. The only other abnormality noted was a steady decrease in the percentage of the neutrophils with a corresponding rise in the percentage of the lymphocytes.

This patient was discharged Jan. 15, 1938, three weeks after operation, and has remained well.

DISCUSSION

Wandering spleen usually remains symptomless until the pedicle undergoes torsion. Colic of mild type, perhaps due to partial twists of the pedicle, and digestive and circulatory disturbances due to pressure on other organs have been reported. Pain, nausea, vomiting, elevation of pulse, temperature, and high leucocyte count usually accompany an acute attack of strangulation. Besides complete torsion of the pedicle, the bowel may become adherent to or compressed by the twisted pedicle.

Splenomegaly is not considered a factor in elongation of the pedicle, for wandering spleen with twisted pedicle has not been reported in cases of Banti's or Gancher's disease, leucemia, or hemolytic jaundice. It occurs most frequently in multiparae. When torsion of the spleen occurs during pregnancy or the puerperium, the prognosis is unfavorable, the mortality rate being 41.7 per cent. In Abell's series of 97 cases, a history of malaria was given in 28. Torsion ranged from one-half to six complete turns. The longest pedicle described measured 25 cm.

A study of the embryology of the spleen may throw some light upon these cases of wide excursion of this organ. Normally the location of the spleen is fairly constant. It is situated in the upper left posterior portion of the abdomen in juxtaposition with the diaphragm. The average adult spleen weighs 160 gm. and measures 12 by 7 by 4 cm.

The posterior border is smooth; the anterior edge is thin and has a number of grooves which from a diagnostic point of view are very important in hypertrophy of the organ. The spleen with its pedicle,

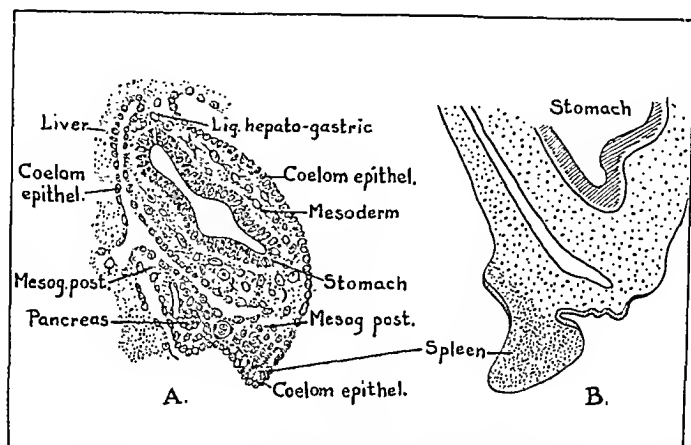


Fig. 2.—Two stages in the early development of the spleen; A, from an embryo of 10.5 mm. (Kollmann); B, from a 20 mm. embryo (Toukoff). (Redrawn from Prentiss: Text Book of Embryology, W. B. Saunders Company, Philadelphia, 1915.)

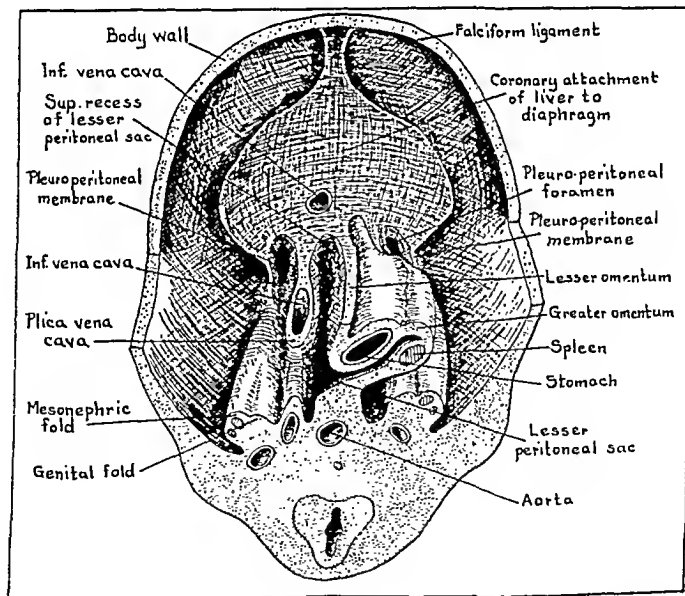


Fig. 3.—A diagrammatic ventral view of the middle third of an embryo 12 to 15 mm. long. (Redrawn from Prentiss: Text Book of Embryology, W. B. Saunders Company, Philadelphia, 1915.)

usually short, may be said to resemble a mushroom on its stalk. Normally the head is free and entirely covered with peritoneum. The stalk or pedicle, however, is supported in position by the lienorenal and

gastrosplenic ligaments and below by the phrenicocolic ligament. The nerves, arteries, veins, and lymphatics which supply the spleen are all enclosed in this pedicle.

The spleen is mesodermal in origin. It appears first in a five-week human embryo (10 mm.) as a thickening of the dorsal mesogastrium when the cells of the peritoneal epithelium divide. It is located in the cranial portion of the greater omentum. See Fig. 2A.⁵ By the time the embryo is 7½ weeks old (20 mm.), the spleen anlage has become fairly well demarcated. See Fig. 2B. The position of the spleen rela-

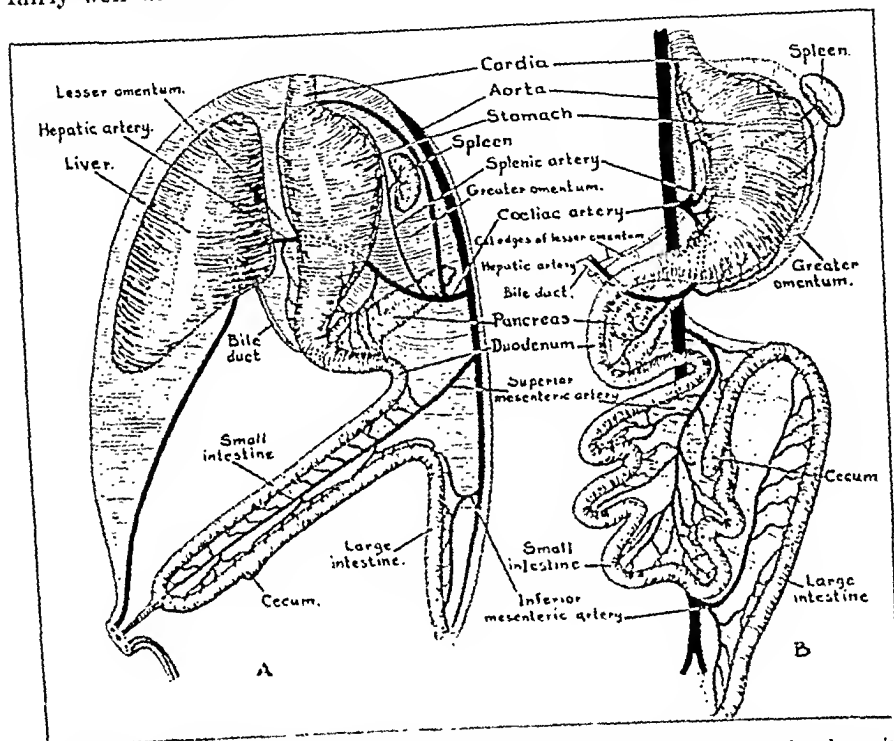


FIG. 1.—Schematic drawing showing early embryonic development of spleen in relation to other structures. (Redrawn from Sabotta and McMurich: *Atlas of Human Anatomy*, Vol. II, G. E. Stechert and Company, New York, 1928.)

tive to omentum and stomach is clearly seen in Fig. 3,⁶ which shows a section through stomach and spleen in an embryo 6 weeks old (12 to 15 mm.).

The septum transversum begins its caudal migration when the embryo is 4 weeks old (7 mm.). With its descent there is constant shifting of all structures. The body cavities increase in size and the liver grows enormously. The descent of the stomach begins when the embryo is 5 weeks old (10 mm.), just when the spleen anlage is making its appearance. It descends rapidly and in two weeks has reached its permanent position below the diaphragm. When the dorsal wall of the stomach descends and rotates to the left, the greater omentum is carried

with it. Since the spleen develops in the greater omentum, its position is affected by the rotating stomach in particular. If attachments between the stomach and the spleen are thin or meager, the spleen gradually increases its range of motion.

When the embryo is six weeks old, the intestinal loop enters the umbilical cord and remains there for three or four weeks until the embryo is about 42 mm. in length (ninth or tenth week). Fig. 4A¹ is a lateral view of the stomach and spleen in a 6-week embryo (12 to 15 mm.) just before the gut enters the umbilical cord. Fig. 4B is an anterior view of these organs after herniation of the gut. The pyloric end of the stomach has rotated more to the right and the spleen has assumed a higher position relative to the greater curvature of the stomach. The intestines have elongated with torsion on the mesentery and shifting of all structures.

DIAGNOSIS AND TREATMENT

Since the spleen may migrate to any part of the peritoneal cavity, the correct diagnosis is rarely made on clinical examination. The condition is often interpreted as appendicitis with peritonitis, abdominal tumor, or ovarian cyst with twisted pedicle. Laparotomy is done for an acute abdominal crisis and the engorged spleen with twisted pedicle is revealed.

Conservative measures are not indicated. Operations which attempt to conserve the spleen which has already sustained damage to its blood vessels and has a tendency to wander from its normal position will afford only temporary relief, if any. These cases later show acute torsion and eventually have to be treated by splenectomy. The loss to the body of the function of the spleen has been offered as an argument in favor of conservative treatment. But other tissues rich in reticuloendothelial cells compensate for the loss of the spleen's function of hematopoiesis.¹

In our case the blood study was carried out through convalescence. The final hospital blood examination Jan. 13, 1938, showed 80 per cent hemoglobin, 3,990,000 erythrocytes, and 8,700 leucocytes. The differential count, however, during the period of Dec. 28 to Jan. 13 showed a steady decrease in the number of neutrophils and a corresponding rise in the number of lymphocytes.

This patient returned for a blood examination April 29, 1938. Her hemoglobin was 80 per cent, with 4,270,000 erythrocytes, and 9,000 leucocytes. The differential count still showed inversion of the number of neutrophils and lymphocytes, with 35 per cent of the former and 62 per cent of the latter; 2 per cent eosinophils and 1 per cent large mononuclears. The platelets numbered 200,000.

The bleeding time was 1 to 1½ minutes; clotting time (venous) 5 to 5½ minutes. The fragility test showed hemolysis beginning at 0.42

and ending at 0.28, as compared with the control fragility test, which began at 0.42 and ended at 0.32. Thus, for the most part, findings were normal. The child had gained 22 pounds and except for a tendency toward constipation had no complaints.

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ENDOMETRIAL TUMORS IN POSTCESAREAN ABDOMINAL LAPAROTOMY SCARS

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SOMEWHERE between the classifications of classical tumor pathology, physiologic hyperplasias, and embryonal maldevelopments, there exists a lesion known, for want of a better name, as endometriosis. This lesion consists of an infiltrative epithelial element resembling uterine mucosa in appearance, embedded in a connective tissue stroma, reinforced occasionally by smooth muscle tissue. The varying conceptions of its nature are reflected in the many names by which it has been called, including adenomyoma, indicating its supposed neoplastic character; endometriosis, indicating its diffuse hyperplastic character; peritonitis adenoides, indicating its supposed inflammatory character; mul-lerianoma, indicating its embryonic origin; and a number of other terms, each of which tends to emphasize one particular aspect of its numerous characteristics. Until its fundamental nature is definitely established, the simple descriptive term, endometrial tumor, is to be preferred as the least committal and yet most inclusive one by which to designate it, the term tumor in this connection being used in its widest sense.

Imperfect as is our knowledge of this lesion, there has grown up a voluminous literature on its clinical manifestations, pathology, and pathogenesis. The latter, particularly, is today still a matter of considerable controversy. To discuss all these subjects comprehensively is beyond the scope of this communication, which is intended to draw attention to an infrequent type of endometrial tumor occurring in post-cesarean laparotomy scars. These tumors, because of the circumstances peculiar to their origin and location, may shed light on the general problem of the pathogenesis of similar tumors occurring in other parts of the body.

SITES OF ENDOMETRIAL TUMORS

A strong predilection exists for the localization of these tumors within or adjacent to the female genital organs, including the uterus, Fallopian tubes, ovaries, broad ligament, and the pelvic and lower abdominal peritoneum. Involvement of the serosal surfaces of the small intestine, appendix, colon, rectum, and bladder is found less commonly. Rela-

tively rare are the extraperitoneal forms of endometriosis, of which there are recognized: a primary form occurring in the navel and groin; and a secondary form occurring in the abdominal wall and pelvic extraperitoneal tissues which have been exposed during operative procedures. It is the latter group of cases with which we are especially concerned in this review, particularly those instances in which the pregnant uterus had previously been opened during a cesarean section. The relative frequency of the various sites of endometrial implants, as reported by Keene and Kimbrough¹ in 119 cases of endometriosis, is as follows:

| | |
|---------------------|-----|
| Ovary | 110 |
| Unilateral | 63 |
| Bilateral | 47 |
| Rectovaginal septum | 6 |
| Umbilicus and ovary | 2 |
| Laparotomy scar | 1 |

INCIDENCE OF POSTCESAREAN ENDOMETRIAL IMPLANTS OF THE ABDOMINAL WALL

Since 1903, when Meyer² reported the first case of an endometrial implant in a laparotomy scar following a ventrosuspension of a non-pregnant uterus, numerous instances of this sequel to gynecological operations have been reported. Three years later, von Fraqué³ reported the first case in which the abdominal wall implantation followed the opening of the pregnant uterus. By 1925 Heaney⁴ was able to collect 29 cases in which endometrial tumors formed in laparotomy scars. These were distributed as follows: 14 following ventrofixation, 2 following hysterectomy, 3 following pelvic operations, 2 following appendectomy, 1 following oophorectomy, and 7 following opening of pregnant uterus.

Hosoi and Mecker⁵ in 1929 collected 87 cases of endometrial tumors in laparotomy scars of which 19 followed cesarean section. To date we have been able to collect a total of 53 cases⁶ following the opening of the pregnant uterus. Most of these cases have been published in the form of individual case reports and short communications, with the result that the occurrence of such a sequel to cesarean operations has not been made generally familiar to surgeons of otherwise wide experience.* Doubtless, as general surgeons and gynecologists become more familiar with this condition, it will be seen to be a lesion of even greater frequency.

Our case is the following:

*We believe that one case attributed to Stavelby by Danforth⁶ is identical with the one attributed to Stavelby by Burnham and Cullen.⁶

CASE REPORT

O. D. (Bronx Hospital No. 80596), a 19-year-old married woman, was admitted with a history that she had been delivered of a child at term by classical cesarean section eighteen months previously. Her postoperative course had been stormy with wound infection and healing by secondary intention. Several weeks thereafter she noticed a small cherry-sized nodule in the abdominal scar, slightly tender on pressure and exquisitely painful at each menstrual period. The nodule had gradually increased in size.



Fig. 1.

Physical examination revealed no abnormalities other than a slightly tender, walnut-sized, irreducible, hard nodule in the midline abdominal scar about 1 cm. below the level of the umbilicus. The nodule was fixed to the deep fascia but was not intimately adherent to the overlying skin.

In view of the characteristic history a diagnosis of endometrial tumor of a post-cesarean laparotomy scar was made and excision performed. The tumor was found to be firmly attached to the fascia and to the subjacent parietal peritoneum as well, although there were no intraperitoneal structures adherent to the nodule. Palpation of the internal genitals through the peritoneal wound revealed no abnormalities. The tumor possessed no well-defined capsule so that a wide excision was performed in order to minimize the possibility of a recurrence.

On section the tumor was seen to be made up of radiating strands of hard fibrous tissue which extended into the surrounding areolar tissue. Between these strands there were islands of mucoid material. Microscopic examination by Dr. Joseph Felsen revealed the tumor to be "endometriosis in a fibrous stroma with areas of myxomatous degeneration and histiocytosis." (Fig. 1.)

Recovery was uneventful, the wound healing by primary union and with complete relief of symptoms.

CLINICAL FEATURES

Endometrial tumors of postcesarean laparotomy scars present a more or less characteristic clinical picture which should offer little diagnostic difficulty to the surgeon familiar with this lesion. Following a period varying from several weeks to several months after the original operation, the patient, a woman generally less than 35 years of age, becomes aware of a hard nodule in the scar. In a few isolated cases a much longer interval elapsed between the time of the original laparotomy and the appearance of symptoms attributable to the endometrial tumor. Pankow⁷ and Mahle and MacCarty⁸ report instances in which an interval of about twenty-five years elapsed between the time of the original laparotomies (appendicectomies) and the discovery of the endometrial tumors. The pathogenesis of such lesions following appendicectomy is a special problem, however, and we shall not attempt an explanation of this phenomenon in that small group other than to state that they are not quite entirely analogous to the postcesarean cases. The longest recorded interval between a cesarean section and the appearance of a cicatricial endometrial tumor is about ten years;⁹ and, even in this case, it is quite likely that the lesion had been present many years before it came to the attention of the patient.

The nodule is generally about the size of a walnut, is quite hard in consistence, and causes little spontaneous pain. Only slight tenderness is present except during the menses, when there is generally a moderate swelling of the tumor, accompanied by severe pain and tenderness localized to the nodule. The concomitance of the pain and the menstrual period is almost a pathognomonic symptom and is found in nearly all the cases,¹⁰ although exceptions to this rule do occur.

In Mengert's case¹¹ the pain was constantly present but was increased during the menses. Rarely, as in Newweiler's case,¹² the pain bears no apparent relationship to the menses; while in von Franqué's⁴ case the tumor produced no pain at all. In one of Harbitz's¹³ cases (Case 13) the tumor regularly produced comenstrual pain, but this pain ceased entirely when the patient became pregnant, only to return when the regular menstrual cycle was restored after delivery.

Undoubtedly the pain is produced by the participation of the endometrial tumor in the corresponding cyclic changes of the normal endometrium lining the uterus, in response to hormonal stimulation. Such

changes produce a miniature menstruation in the tumor itself with consequent increase in tension and attendant pain. Such an hypothesis is supported by the observation of Heaney⁴ and others, who noted that the skin overlying the tumor became bluish in color during the menses. In some cases, notably those of Stavely,¹⁴ Orestano,¹⁵ and Ricek,¹⁶ the skin over the tumor broke down at such times with the periodic discharge of hemorrhagic fluid. Such an occurrence would lead one to suspect the presence of a uteroparietal fistula, but probing of the sinus or x-ray examination after the injection of an opaque medium into the sinus should serve to effect the differentiation. Rarely, as in Lützenkirchen's case,¹⁷ the endometrial tumor itself communicates with the uterine cavity, in which instance the anatomic connection should be demonstrable at the time of the operative exploration.

Occasionally the nodule may be mistaken for a small ventral hernia containing incarcerated omentum, or for a desmoid tumor;¹⁸ but a careful inquiry into the history and the periodicity of the pain should serve to permit a proper differential diagnosis.

PATHOLOGY

Endometrial tumors usually take the form of discrete well-localized nodules, although Williams¹⁹ has reported an instance of a diffuse infiltration of the entire scar. The nodules are usually single, but cases in which two nodules have been found are recorded.^{20, 21} There appears to be no predisposition to any particular localization in the upper or lower portions of the wound, and implants have been found on either side of the midline in cases where the transverse Pfannenstiel incision had been used.²² Localization may take place in any or all of the layers of the abdominal wall comprising the laparotomy cicatrix, the most usual site being the superficial surface of the anterior rectus sheath. In Berkeley's case²³ the nodule involved only the skin and subcutaneous tissue. Harbitz¹³ mentions one case (Case 9) in which the nodule was entirely in the subcutaneous tissues. In other reports^{24, 25} all the layers of the abdominal wall were involved. As a rule the parietal peritoneum is not involved. Invasion of the intraperitoneal structures, while unusual, has been noted by several writers,^{26, 27} the adherent structure generally being the fundus of the uterus. Such a finding does not necessarily mean that there is direct continuity of endometrial tissue from the uterus to the parietal implant, for microscopic examination may reveal the adhesions to be purely fibrous in character.²⁷

The tumors are very firm and their consistence has aptly been compared by Lemon and Mahle²⁸ to that of a uterine fibromyoma. Section reveals the bulk of the tumor to be comprised of interlacing bands of white and gray fibrous tissue which penetrate beyond the ill-defined limits of the tumor into the adjacent areolar tissue, fascia, muscle, and

peritoneum. Irregular, softer areas between the fibrous bundles consist of glandular tissue and small cystic collections of old blood and mucoid material. In one case, Harbitz' Case 14, the cyst formation was so pronounced as to constitute the bulk of the tumor. Serial sections have demonstrated²⁹ that these apparently isolated islands of epithelial tissue actually communicate with one another.

Microscopically the epithelial element is found to consist of typical endometrial mucosal cells arranged in tubules and small cysts resembling pseudoglomeruli at times. All the stages of the menstrual cycle are observed in them, depending upon the time of the excision of the specimen in relation to the patient's own menstrual cycle. In one of Harbitz' cases (Case 4), where excision was performed one day before the onset of the regular menstrual period, the specimen exhibited the characteristic progestational proliferation one would expect to find in the normal premenstrual endometrium. This participation of the tumor in the cyclic changes of the normal endometrium is even more strikingly shown by the experience of Martin, Michon, and Pigeaud,³⁰ who excised an endometrial tumor of a laparotomy scar during a subsequent cesarean section at term, and who found, on histologic examination of the specimen, that the tumor cells exhibited the decidual reaction of pregnancy.

The nonepithelial elements of the tumor consist of a varying amount of connective tissue which may or may not be accompanied by smooth muscle fibers.³¹

PATHOGENESIS

Many ingenious hypotheses have been promulgated to explain the occurrence of ectopic endometrial tissue ever since this lesion was first observed. In 1896 von Recklinghausen³² offered the theory that these tumors represented misplaced embryonic rests from the original Wolffian urogenital epithelium. Such an explanation, while conceivably applicable to cases of pelvic endometriosis, is obviously untenable in the post-operative cicatricial cases, for it has been established beyond controversy that the anterior abdominal wall is not involved by the Wolffian body at any stage of its development.

In 1908 Cullen³³ observed evidences of infiltration of the uterine wall by the basal layers of the endometrium in his cases of uterine endometriosis and concluded that direct invasion was the mode by which the endometrial epithelium migrated to other portions of the genitals. While such an hypothesis is fairly well supported in those cases in which the ectopic localization is limited to the immediate vicinity of the uterus, it becomes somewhat farfetched if one attempts to explain other instances of more distant implantation, such as have been commonly observed since Cullen's original reports. Certainly this theory could scarcely explain the occurrence of subcutaneous extraperitoneal nodules in the group of postcesarean cicatricial involvements.

In 1924 Halban³⁴ elaborated Cullen's hypothesis, and put forward a conception of lymphogenous "metastatic hysterio-adenosis" as the explanation of more distant endometrial localizations. Such a theory, however, would presuppose the existence of unusual and improbable lymph channels from the uterus to the intestinal serosa, navel, etc. Furthermore, in the cases of endometriosis of the groin, it is not unusual to find the endometrial tumor adjacent to but not actually involving the inguinal lymph nodes. Here also it would appear that the hypothesis is not sufficiently inclusive to explain the formation of endometrial tumors in laparotomy scars.

More fundamental in its tenets than any of the preceding assumptions is the theory of serosa-epithelial metaplasia, subscribed to by numerous observers, notably Novak³⁵ in this country and Nicholson³⁶ in Great Britain. These investigators point out the close relationship of the germinal epithelium to the mesothelial celomic lining, both in the embryo and in the adult organism where the surface epithelium of the ovary is directly continuous with the peritoneum itself. This they consider as evidence of the potentiality inherent in all peritoneal mesothelium for the formation of true germinal epithelium under the influence of certain biological stimuli. Subscribers to this theory believe that the latent capacity of the peritoneal serosa for epithelial transformation is more or less directly proportional to its proximity to the line of normal serosa-epithelial transition (i.e., at the ovary). They point to the preponderance of involvement of the pelvic structures by endometriosis in support of this view and likewise indicate that even in the postcesarean laparotomy cases the endometrial tumors occur at a level below the umbilicus. Opponents of this theory reply, however, that such localization in wounds below the umbilicus is due merely to the fact that most incisions for gynecological or obstetrical operations are made below the umbilicus. This contention is supported by the observation of German,²¹ who found two endometrial tumors in a postcesarean laparotomy scar, one of which was in the upper angle of the wound above the level of the umbilicus. The most serious objection to the theory of serosal metaplasia, however, is its failure to explain adequately the numerous instances of completely extraperitoneal localization of endometrial tumors in the abdominal laparotomy scars following cesarean sections and other gynecological operations.

A tremendous impetus to the study of endometriosis followed the publication in 1921 of Sampson's classical observations³⁷⁻³⁹ and well-thought-out views on the pathogenesis of this lesion. He attributed ectopic localizations of endometrial tissue to the dissemination and implantation of adult, differentiated, viable bits of endometrium which become engrafted upon a suitable metastatic site, there to proliferate if nutritive and other conditions permit of its survival. By this theory the usual intraperitoneal forms of endometriosis are explained by the

extrusion of bits of viable endometrium from the fimbriated ends of the Fallopian tubes due to partially retrograde menstrual flow. He further supported his conception by successful tissue culture experiments, since confirmed by other investigators, by which he showed that portions of endometrium cast off during menstruation are viable.

Sampson's theory is particularly applicable to our own group of cases for it is easy to predicate that a microscopic fragment of endometrium detached from the uterine wall during the operation may become lodged in the tissues of the abdominal wound, and, under favorable conditions, continue to grow there as a tissue transplant. The actual detachment of the uterine mucosa may be accomplished by the scalpel or, as suggested by Lochrane,⁴⁰ by the passage of a needle into or through the endometrium during suturing. Additional evidence in favor of this theory is provided by Violet's⁴¹ and Prager's⁴² reports of extraperitoneal endometrial tumors of the perineum following deliveries from below in which wide tears into the perineal tissues occurred during labor.

In view of the fact that Sampson's implantation theory is the only one of the entire group which explains extraperitoneal as well as intraperitoneal localizations of endometriosis, we believe it should be accepted as the most valid comprehensive theory of the pathogenesis of this lesion in all locations.

PROPHYLAXIS

One practical application of the implantation theory in the prevention of cicatricial endometrial localization is a modification of the technique of hysterotomy for cesarean section or other purposes. Care should be taken to provide adequate protection of the abdominal wound margins by covering them with gauze pads or rubber tissue as suggested by Bonney.⁴³ Furthermore, it is recommended that, following the closure of the peritoneum, the wound be flooded with ether or absolute alcohol to remove not only loose and traumatized portions of fatty tissue but likewise to devitalize or remove mechanically any minute fragments of endometrium which might otherwise have been allowed to gain a nutritive foothold in the wound. Schwarz⁴⁴ advises that a low cervical incision be made where possible when performing a cesarean section. This suggestion is made on the presumption that the cervical mucosa thus exposed is less likely to become implanted in the abdominal wall. In this connection, however, it is interesting to note that in Rieck's case the occurrence of an endometrial tumor in the scar followed a Latzko cesarean section.

TREATMENT

In most cases complete excision of the nodule or nodules is feasible and is advisable as the procedure of choice. Care should be taken to effect a wide dissection into normal surrounding tissues, because these

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tumors do not have a well-defined capsule. Usually it is not necessary to open the peritoneum, but, unless the tumor is definitely not attached to the peritoneum at all, it is advisable to remove the underlying peritoneum along with the tumor. If local excision is impossible for technical reasons or because of the general condition of the patient, treatment should consist of the application of deep radiotherapy to the ovaries as is done in inoperable intraperitoneal endometriosis. By this means the menstrual cycle is halted and the endometrial tumor, though still present, does not produce the usual comenstrual pain.

SUMMARY

1. Attention is directed to a group of endometrial tumors occurring in postcesarean abdominal wall laparotomy scars.
2. We believe these tumors to represent proliferations of fragments of uterine mucosa inadvertently transplanted into the abdominal wound during a previous hysterotomy.
3. Clinical features, including the pathognomonic comenstrual pain, pathology, and pathogenesis are discussed.
4. Prophylaxis and treatment are outlined.

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the field of peripheral circulatory disease, it is well known that blocking the ulnar, median, posterior tibial, or peroneal nerves normally produces a vasodilatation with loss of sweating in the cutaneous zones innervated by these nerves.

Recognition of the fact that surgical or traumatic division of a peripheral nerve will denervate the blood vessels in the regions innervated by that nerve gives us a clue to the etiology of the various vasomotor and nutritional disturbances which ensue. In 1934 Freeman, Smithwick, and White^{1, 5} published the results of their classic experiments on the sensitization of blood vessels in the sympathetomized human extremity to circulating adrenaline. A detailed account of these experiments, together with their background and their practical application to the problem of sympathectomy, is given by White.⁶ A brief exposition of their findings is sufficient for our thesis. Their experiments were performed on individuals suffering from Raynaud's disease, in whom the postganglionic sympathetic fibers to the blood vessels of the upper extremities had been destroyed by cervicothoracic sympathetic ganglionectomy. They found that, beginning around the seventh to the fourteenth postoperative day, an intravenous injection of a quantity of adrenaline insufficient to cause vasoconstriction in normal regions would produce an intense arteriolar constriction in the fingers of the denervated extremity, as evidenced by decreases in their skin temperatures. These denervated arterioles were similarly hypersensitive to other vasoconstricting stimuli, as exposure to cold.

We became interested in determining whether similar sensitization would occur in normal arterioles following traumatic division of a peripheral nerve. Since arterioles thus sensitized may ultimately become permanently constricted with resultant loss of nutrition to the tissues they supply, the so-called trophic function of nerves, and the vasomotor and nutritional changes following their division, on this basis, could be explained. An opportunity to test this hypothesis was afforded us with the admission of a case of complete traumatic division of the median and partial division of the ulnar nerves at the left wrist.

CASE REPORT.—A. D., No. 187161, was admitted to Surgical Service A of Cleveland City Hospital with a deep laceration of the left wrist sustained in an auto accident. He was taken to the surgery at once, and the wound was explored. It was found that, in addition to other structures, the median nerve was completely severed and the ulnar nerve partially severed. The divided ends were united by suture.

The following day, he presented complete anesthesia of the palm and volar surfaces of all the digits, with the exception of a narrow strip at the outer border of the fifth finger and hypothemal eminence. The anesthetic zones were red, hot, and dry, exactly similar in appearance to a recently sympathetomized hand.

THE ETIOLOGY OF VASOMOTOR AND NUTRITIONAL CHANGES FOLLOWING PERIPHERAL NERVE SECTION

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FOR many years surgeons have known that vasomotor and nutritional changes may occur in regions (particularly the digits) innervated by a peripheral nerve which has been sectioned. However, the cause of these phenomena has remained obscure. Following section of a peripheral nerve, the cutaneous area innervated by it becomes at once hot and dry. This initial period of vasodilatation lasts for only a relatively short period of time. It is followed by vasoconstriction, as indicated by a drop in skin temperature. Unless rapid regeneration of the divided nerve takes place, the denervated part becomes cold to palpation; color changes appear in the skin, atrophy of skin, subcutaneous tissue, and bone ensues; characteristic changes occur in the nails; and ulcers which fail to heal may appear. While some of these changes may be explained on the basis of disuse, lack of active function does not tell the entire story. Likewise, the theory of the "trophic" function of nerves is more specious than convincing. Perhaps through the application of certain newer anatomic and physiologic principles, an explanation of these phenomena may be forthcoming.

The initial phase of vasodilatation with loss of sweating presents a picture similar to that following sympathetomy. In fact, it is based on the severance of postganglionic sympathetic neurones. Kramer and Todd¹ were the first to show that in the upper extremities the postganglionic sympathetic fibers to the blood vessels are distributed within the branches of the brachial plexus. Potts,² working in Dr. Todd's laboratory, found the same condition obtaining in the inferior extremities; namely, that the postganglionic sympathetic neurones to the blood vessels are carried within the branches of the lumbosacral plexus. Up to this time it had been supposed that vasomotor fibers in the extremities were carried in the adventitia of the main arterial trunks and their branches, as they are in the visceral vessels. The aforementioned work coming from Dr. Todd's laboratory has been confirmed many times. Woolard and Phillips³ demonstrated that the sympathetic nervous innervation of the subpapillary arterioles corresponds to the somatic cutaneous innervation. To those working in

the field of peripheral circulatory disease, it is well known that blocking the ulnar, median, posterior tibial, or peroneal nerves normally produces a vasodilatation with loss of sweating in the cutaneous zones innervated by these nerves.

Recognition of the fact that surgical or traumatic division of a peripheral nerve will denervate the blood vessels in the regions innervated by that nerve gives us a clue to the etiology of the various vasomotor and nutritional disturbances which ensue. In 1934 Freeman, Smithwick, and White^{4, 5} published the results of their classic experiments on the sensitization of blood vessels in the sympathectomized human extremity to circulating adrenaline. A detailed account of these experiments, together with their background and their practical application to the problem of sympathectomy, is given by White.⁶ A brief exposition of their findings is sufficient for our thesis. Their experiments were performed on individuals suffering from Raynaud's disease, in whom the postganglionic sympathetic fibers to the blood vessels of the upper extremities had been destroyed by cervicothoracic sympathetic ganglionectomy. They found that, beginning around the seventh to the fourteenth postoperative day, an intravenous injection of a quantity of adrenaline insufficient to cause vasoconstriction in normal regions would produce an intense arteriolar constriction in the fingers of the denervated extremity, as evidenced by decreases in their skin temperatures. These denervated arterioles were similarly hypersensitive to other vasoconstricting stimuli, as exposure to cold.

We became interested in determining whether similar sensitization would occur in normal arterioles following traumatic division of a peripheral nerve. Since arterioles thus sensitized may ultimately become permanently constricted with resultant loss of nutrition to the tissues they supply, the so-called trophic function of nerves, and the vasomotor and nutritional changes following their division, on this basis, could be explained. An opportunity to test this hypothesis was afforded us with the admission of a case of complete traumatic division of the median and partial division of the ulnar nerves at the left wrist.

CASE REPORT. A. D., No. 187161, was admitted to Surgical Service A of Cleveland City Hospital with a deep laceration of the left wrist sustained in an auto accident. He was taken to the surgery at once, and the wound was explored. It was found that, in addition to other structures, the median nerve was completely severed and the ulnar nerve partially severed. The divided ends were united by suture.

The following day, he presented complete anesthesia of the palm and volar surfaces of all the digits, with the exception of a narrow strip at the outer border of the fifth finger and hypothenar cutaneous. The anesthetic zones were red, hot, and dry, exactly similar in appearance to a recently sympathectomized hand.

On the thirteenth day following the injury, skin temperature readings, stabilized at a room temperature of 24° C., were taken from the pads of the distal phalanges of the fingers of both hands. They were:

| | RIGHT (CONTROL) | LEFT (ANESTHETIC) |
|---------------|-----------------|-------------------|
| First finger | 32.2 | 33.2 |
| Second finger | 32.0 | 33.0 |
| Third finger | 31.7 | 33.0 |
| Fourth finger | 32.4 | 33.3 |
| Fifth finger | 32.1 | 33.5 |

It is seen that at this time the skin temperatures of the anesthetic fingers were higher.

Skin temperature readings, stabilized at a room temperature of 23.4° C., were taken from the same spots one week later and were:

| | RIGHT (CONTROL) | LEFT (ANESTHETIC) |
|---------------|-----------------|-------------------|
| First finger | 31.1 | 29.1 |
| Second finger | 31.1 | 28.6 |
| Third finger | 31.1 | 28.8 |
| Fourth finger | 31.8 | 28.6 |
| Fifth finger | 31.6 | 28.3 |

Evidently something had occurred in the intervening week, for now the skin temperatures of the anesthetic fingers were not only relatively lower, but were absolutely subnormal. At room temperatures above 22.5° C., stabilized skin temperatures of the fingers should normally be at least 31° C.

Immediately following the taking of these readings, 0.35 c.c. of a 1 per cent solution of neosynephrine hydrochloride was injected subcutaneously in the left leg, and skin temperature readings from the same points were taken at five-minute intervals. Fortunately for the purposes of this experiment, the room temperature began to rise rapidly from 23.4 to 26.5° C. following the injection. Thus, a drop in the skin temperatures of the anesthetic finger pads in response to the injection would be very significant; and particularly so if, despite the injection, the control readings from the normal finger pads should rise in response to the increasing room temperature. The readings actually obtained were:

RIGHT (CONTROL)

| FINGER | FIRST | SECOND | THIRD | FOURTH | FIFTH |
|------------------------|---|--------|-------|--------|-------|
| RESTING TEMPERATURES | 31.1 | 31.1 | 31.1 | 31.8 | 31.6 |
| SUBCUTANEOUS INJECTION | 0.35 C.C. 1% NEOSYNEPHRINE HYDROCHLORIDE LEFT LEG | | | | |
| 5 min. later | 31.1 | 31.0 | 31.3 | 32.0 | 32.0 |
| 10 min. later | 31.5 | 31.5 | 31.7 | 32.0 | 32.0 |
| 15 min. later | 31.8 | 31.7 | 31.7 | 32.0 | 32.1 |
| 20 min. later | 32.0 | 31.9 | 31.9 | 32.2 | 32.4 |
| 25 min. later | 32.0 | 32.0 | 32.3 | 32.5 | 32.5 |
| 30 min. later | 32.3 | 32.2 | 32.5 | 32.5 | 32.5 |

LEFT (ANESTHETIC)

| FINGER | FIRST | SECOND | THIRD | FOURTH | FIFTH |
|------------------------|---|--------|-------|--------|-------|
| RESTING TEMPERATURES | 29.1 | 28.6 | 28.8 | 28.6 | 28.3 |
| SUBCUTANEOUS INJECTION | 0.35 C.C. 1% NEOSYNEPHRINE HYDROCHLORIDE LEFT LEG | | | | |
| 5 min. later | 28.8 | 28.5 | 28.3 | 28.1 | 28.1 |
| 10 min. later | 28.2 | 27.7 | 27.5 | 27.3 | 27.1 |
| 15 min. later | 27.8 | 27.5 | 27.2 | 27.0 | 27.0 |
| 20 min. later | 27.4 | 27.1 | 26.7 | 26.6 | 26.7 |
| 25 min. later | 27.1 | 26.7 | 26.4 | 26.4 | 26.4 |
| 30 min. later | 26.6 | 26.2 | 26.1 | 25.9 | 26.1 |

It is seen that, whereas the control temperatures rose, those from the anesthetic finger pads decreased, the drop reaching its maximum 30 minutes from the time of injection of the vasoconstricting drug.

The phenomenon of sensitization of normal human arteriolar musculature to a vasoconstricting stimulus is clearly demonstrated. That such sensitization to vasoconstricting influences could be the etiology of vasomotor and nutritional changes in denervated tissues is certainly possible. Unfortunately, there is no way of preventing the onset of this sensitization. However, it should be possible to keep its deleterious effects at a minimum until regeneration of the divided nerve has taken place. The denervated part should be kept warm at all times, emotionally upsetting situations should be avoided, and the use of tobacco interdicted. In addition, various measures designed to produce a regional vasodilatation should be employed, such as hot paraffin baths, massage, diathermy, and mecholyl iontophoresis.

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A NEW MODIFICATION OF SUBARACHNOID ALCOHOL INJECTION FOR THE BILATERAL BLOCKING OF THE LOWER SACRAL NERVES IN INTRACTABLE PAIN OF THE PELVIC VISCERA

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(From the Surgical Service of the Massachusetts General Hospital)

THE intrathecal injection of alcohol to block the posterior sensory roots of the spinal nerves was proposed by Dogliotti^{1, 2} as a substitute for posterior rhizotomy or section of the spinothalamie tract. During the last seven years, this method has come into fairly widespread use, and reports of numerous successful results have been published.³⁻⁶ Radical as this method at first seemed, it is now generally realized that it carries but little greater risk of injury to the motor or bladder pathways than does cordotomy; in addition, it can be used in patients with hopelessly advanced malignant disease who could stand no open operation. The chief objections to subarachnoid alcohol injection are its narrow margin of safety and the fact that doses of less than 1 c.c. of absolute alcohol so often fail to produce adequate or lasting analgesia. The limitations of the method have been brought out very clearly by the neuro-pathologic studies of Aird and Naffziger.⁷ When two injections have to be made for bilateral pain, the risks of failure or complication are considerable.

A modification of Dogliotti's method of subarachnoid alcohol injection has been developed in the Neurosurgical Clinic of the Massachusetts General Hospital which has given uniformly successful analgesia over the sensory distribution of the lower sacral nerves on both sides* (Fig. 1). Pain limited to the penis, the posterior half of the scrotum or labia, the perineum and saddle area in the buttocks is seen not infrequently in inoperable cancer and certain other diseases of the bladder, prostate, and lower rectum. It can be a particularly distressing type of pain which remains localized to this area as long as the disease is confined to the neighboring soft tissues and has not spread to bone or involved the upper trunks of the lumbosacral plexus. Although the method has been in satisfactory use for over two years, it seemed best not to report it until it had been subjected to a sufficient number of trials to demonstrate that it could be counted on to give consistent results and to be free from serious risk.

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*Adson,⁸ in a report of 10 cases treated by Dogliotti's intrathecal alcohol injection at the Mayo Clinic, has mentioned the possibility of blocking the lowest sacral nerves bilaterally. He has used a somewhat similar technique in two cases of anal and vulval pruritus.

As in Dogliotti's technique for blocking posterior nerve roots on one side, bilateral infiltration of the roots of the lower three sacral nerves in the caudal end of the subarachnoid space depends on the fact that absolute alcohol (specific gravity 0.775 at body temperature) is lighter than spinal fluid (specific gravity 1.005). However, instead of making the injection in the lateral position, the patient is laid prone and the sacrum elevated by lowering the two ends of the operating table. The lower termination of the subarachnoid space then becomes the highest



Fig. 1. Area of anesthesia following bilateral alcohol injection of lowest sacral nerves (Patient 11). Solid black indicates area of lasting analgesia. The larger area down the posterior thighs which is enclosed by black lines indicates outlying zone of hypoaesthesia immediately after injection. This disappeared within a few hours.

point in the cerebrospinal fluid column. (Fig. 2.) Lumbar puncture can usually be carried out in this position, either between L4 and L5 or between L5 and S1. When the needle enters the subarachnoid space, spinal fluid must be aspirated with a syringe, because it usually is not under sufficient pressure to flow out spontaneously. Only a minimal amount of fluid should be withdrawn to check the position of the needle. One to 12 c.c. of sterile absolute alcohol* should then be injected. The

*The use of sterilized alcohol is recommended for this purpose, as certain spore-forming microorganisms may remain viable even in absolute alcohol. This can be obtained in ampoules from the Intravenous Products Company of North America, 222 Fourth Avenue, New York, N. Y.

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Received for publication, June 9, 1938.

*Adson,⁸ in a report of 40 cases treated by Dogliotti's intrathecal alcohol injection at the Mayo Clinic, has mentioned the possibility of blocking the lowest sacral nerves bilaterally. He has used a somewhat similar technique in two cases of anal and vulvar pruritus.

TABLE I

| PATIENT | DIAGNOSIS | PREVIOUS OPERATION | SYMPTOMS | ALCOHOL INJECTION | COMMENT |
|---------------|---|--|---|---|---|
| 1 Male, 65 | Carcinoma of rectum, recurrent in perineal scar | Combined abdomino-perineal resection 1 yr. previously | Good result for 9 mo., then reopening of perineal wound with bloody discharge and deep perineal pain; liver enlarged and nodular | 4/9/36: 1.2 c.c. 95% alcohol | Complete relief for 2 wk., then recurrence; unfortunately he lived too far away to return for reinjection; no disturbance in urination |
| 2 Male, 69 | Carcinoma of rectum | Colostomy 2½ yr. previously | Functioning colostomy; deep perineal pain and large, nodular liver | 4/17/36: 1.2 c.c. 95% alcohol | Local doctor wrote that, as far as he could judge, the patient "did not suffer any great amount of pain"; there was no disturbance in urination, but he was able to retain his rectal discharge less well. Died 6 mo. |
| 3 Male, 51 | Carcinoma of bladder | 3/23/36: Resection and electrocoagulation 10/23/36: Transurethral fulguration Suprapubic tube 9/22/36: Suprapubic cystostomy and permanent drainage | Severe recurrent pain from sacrum to penis with hematuria; delayed and in poor condition Patient bedridden and unable to rest on account of painful spasms in perineum and penis | 11/16/36: 1 c.c. 95% alcohol 1/8/37: 1.1 c.c. absolute alcohol | Severe sacral and penile pain entirely relieved. Died 11 days later of terminal pneumonia |
| 5 Male, 68 | Carcinoma of bladder | 3/26/37: Bladder fulguration and implantation of radium seeds; suprapubic cystostomy Suprapubic tube | Bad pain on urination which radiates from sacrum through perineum to penis; much bladder irritability and frequency | 3/27/37: 1 c.c. 95% alcohol 6/4/37: 1.1 c.c. 95% alcohol | Complete relief of pain for 15 mo.; his rectum remains insensitive, so that he occasionally soils himself when his bowels are loose; at 20 mo., there is a slight recurrence of opiates; bladder full of cancer |
| 6 Male, 67 | Carcinoma of prostate | 2/22/37: Viscetomy and permanent suprapubic cystostomy | Excruciating pain at base of penis on every movement | 4/10/37: 1.1 c.c. absolute alcohol | Complete relief for a month, then a gradual recurrence, for which injection was repeated; discharged on following day; at 11 mo. he complains of some suprapubic discomfort, but his old perineal pain seems to remain relieved |
| | | | | | Complete relief of perineal pain with definite hypoaesthesia for 10 mo.; at end of a year he is beginning to have a slight recurrence, but can still get along without morphine; at first there was some relaxation of anal sphincter, but no leakage of less he had diarrhea |

alcohol floats upwards to the termination of the subarachnoid space and bathes the caudal ends of the third, fourth, and fifth pairs of sacral nerve roots. The injection produces no sensation beyond a vague feeling of warmth, but causes rapid anesthesia of the buttocks over a radius of about three to six inches around the anus, a little way down the posterior aspect of the thighs, and forward over the perineum, posterior scrotum, and penis (Fig. 1). In order to allow the alcohol to become fixed in this area, it is necessary to keep the patient perfectly quiet and in the same position for over an hour. A moderate dose of morphine is helpful to prevent discomfort and restlessness. After the patient has been re-

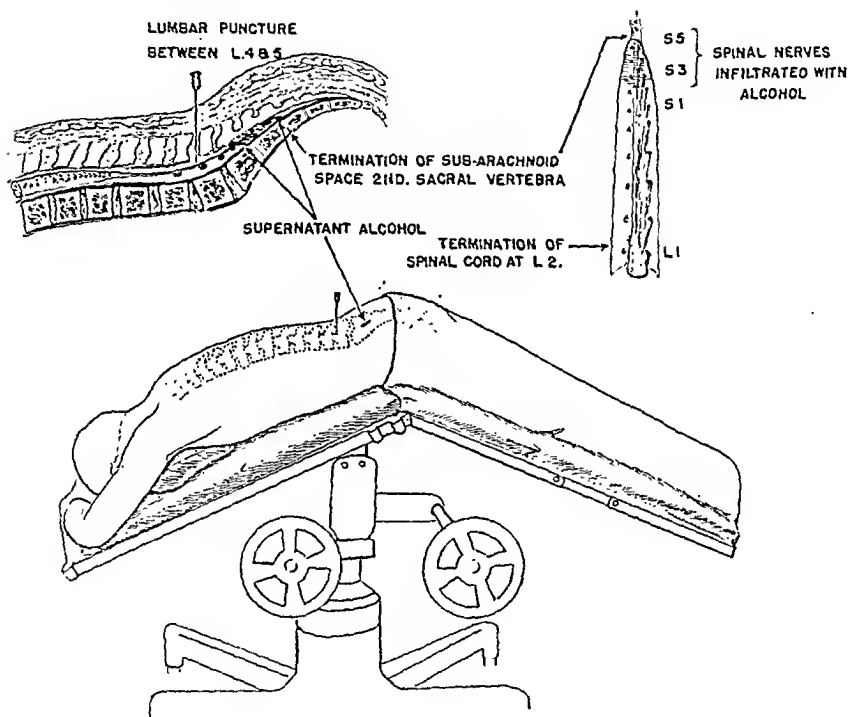


Fig. 2.—Technique of bilateral subarachnoid alcohol block of lower sacral nerves.

turned to bed, it is only necessary to insist on the routine flat in bed position in order to prevent headache, which is liable to follow any lumbar puncture if the head is raised too soon. The patient can ordinarily be up and walking around the next day, as though nothing more than a diagnostic puncture had been performed.

Table I contains a brief summary of the case histories, past treatment, and the results of subarachnoid alcohol injection of the lower sacral nerves in six patients. The loss of cutaneous sensation has been confined to the distribution of the three lowest pairs of sacral nerves. While there was immediate relief of pain in every instance, the duration of re-

dition rendered cordotomy out of the question, but the intensity of their pain made them quite willing to accept the possibility of a catheter existence.

In conclusion, subarachnoid alcohol injection of the lower sacral nerves is not intended to supplant cordotomy in patients who are favorable operative risks, but for those who are in too poor condition and have only a short time to live, it is a most valuable substitute.

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lief has been somewhat variable. In Patient 4, who has been followed over the longest period, complete freedom from pain lasted for fifteen months, and at twenty months he still does not require opiates. If the sensory fibers recover, reinjection is a simple matter. Patients 1 and 5 had a gradual recurrence of their former pain. The latter was treated successfully by reinjection, but the former lived at such a distance that it was impossible for him to return to the hospital on account of his poor general condition.

Complications in these particular patients have been minimal. None have noted any weakness of their legs. As a rule the injection produces some relaxation of the anal sphincter and an insensitive lower rectum, so that patients may soil themselves when their bowels are loose. None, however, have complained of frequent fecal incontinence. As far as bladder function is concerned, the two patients with rectal cancer who were not already on constant drainage observed no impairment in their ability to urinate, although it seems too optimistic to believe that this will consistently be the case.

There is a valid anatomical explanation for these clinical observations. In spite of the fact that in the lower cauda equina the sensory and motor roots lie so close together that some of the injected alcohol is certain to come in contact with the latter, it would be most unlikely for the motor fibers to the legs to be involved, because the action of the alcohol is so accurately confined to the lowest sacral roots below the origins of the sciatic nerve. In addition the observations of Gasser and Erlanger⁸ have shown that the large heavily myelinated axones to skeletal muscle are far less vulnerable to the action of drugs, such as procaine and alcohol, than the thinly myelinated or unmyelinated pain fibers. Inasmuch as the parasympathetic axones which conduct the principal impulses mediating urination and defecation are unmyelinated, it may seem surprising that these functions are not more severely impaired. Anatomical studies of Simmons⁹ have traced the bladder outflow to the second and third sacral roots but have shown that the innervation of the lower rectal segment and the anal sphincters is given off one segment lower. This is probably the explanation why three of these patients noted a slight disturbance in bowel control.

In spite of the fact that bladder paralysis may be infrequent, sub-arachnoid alcohol injection undoubtedly carries a greater risk of this complication than bilateral cordotomy. It should therefore not be recommended for any patient who is not already on constant drainage or is not prepared to accept it. Inasmuch as the majority of patients with intractable pain in this area are suffering from cancer of the prostate or bladder neck, the necessity for an indwelling catheter or suprapubic cystostomy has usually been reached. Injection was performed in the two patients with rectal carcinoma because their poor general con-

in a separate category. The reason becomes apparent upon an inspection of the table, and the features of the lesion will be referred to briefly in a succeeding paragraph. The identification of the various pathologic processes mentioned in the classification is based on personal observations. The latter consist partly of a study of roentgen features and operative findings, and partly of observations of clinical features and of autopsies. Unfortunately, a comparison with the observations of others cannot be made because of the paucity of literature on the subject. The classification which we have drawn up does not purport to be all inclusive, its particular purpose being to emphasize the surgical aspects of the disease under discussion. Arbitrary lines have been drawn and undoubtedly result in sharper cleavage between lesions than is actually the case. However, the classification epitomizes the observations which we have made.

A CLASSIFICATION OF ACUTE PULMONARY SUPPURATION DUE TO AEROBES, WITH SPECIAL REFERENCE TO SURGICAL ASPECTS

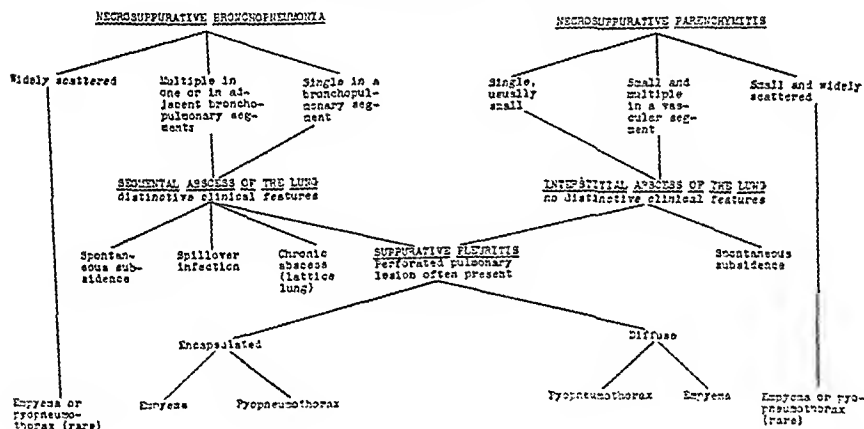


Fig. 1.

The features of necrosuppurative bronchopneumonia now will be outlined. The disease is characterized: (1) pathologically, by the co-existence of suppuration and necrosis involving one or more bronchopulmonary segments;² (2) clinically, by the occurrence of fever and cough, and the expectoration of odorless pus; (3) roentgenologically, by the presence of one or more areas of pneumonic infiltration; (4) bacteriologically, by the presence of aerobic, pus-producing bacteria in the sputum.

Although amplification of this bare outline is desirable, lack of space does not permit of a discussion of the variations which have been noted. Fever is often high, may be remittent, and is attended

²The term "bronchopulmonary segment" has been designated by Glass (Am. J. Roentgenol. 31: 1934) as a secondary bronchus with its tributary bronchioles and parenchyma. Each segment is separate and distinct from adjacent ones.

ACUTE AEROBIC (NONPUTRID) ABSCESS OF THE LUNG

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A. INTRODUCTION

THE most serious pulmonary complication of so-called "acute suppurative bronchopneumonia," is nonputrid (aerobic) pulmonary abscess. Until recent years we considered the term "abscess of the lung" to be practically synonymous, from the clinical standpoint, with putrid (anaerobic) abscess, and regarded the nonputrid (aerobic) varieties to be rare and of clinical importance only when complicated by infection of the pleura.¹ As a result of a great increase in the incidence of "suppurative bronchopneumonia" in the past few years, however, and its recognition as a clinical entity, we have encountered a substantial and possibly disproportionate increase in the number of cases of aerobic abscess. Thus we have altered completely our original views and now regard nonputrid abscess of the lung as a not uncommon disease of considerable clinical significance. It is also a disease for which, in our opinion, surgical consideration and operative treatment are required under certain circumstances. Because we have not found an adequate clinical survey of the subject in the literature, we shall present it in some detail. Inasmuch as this paper is based on personal observations and experiences, surgical aspects will of necessity be stressed, and operative treatment will receive special consideration.

B. THE CAUSATIVE BRONCHOPNEUMONIA

In order to deal logically with the subject of nonputrid pulmonary abscess, the characteristics of the causative bronchopneumonia should be noted. We shall proceed, therefore, with a brief discussion of some basic features. Pathologically, there are two prominent characteristics of the bronchopneumonia from which a nonputrid pulmonary abscess is derived, namely *suppuration* and *necrosis*. The last appears to be an essential and oftentimes outstanding feature of the pathologic process. The term "suppurative bronchopneumonia," which is in common use, does not emphasize this feature (necrosis) and therefore seems inadequate. Accordingly, we have devised and shall employ the more descriptive term "necrosuppurative bronchopneumonia" which denotes the coexistence of both characteristics. In the classification which we have drawn up, "necrosuppurative parenchymitis" has been placed

(1) are usually much smaller than the segmental variety, (2) usually are multiple, (3) may lie superficially or deeply in the lung, (4) are of varied etiology, and (5) ordinarily present no clinical (and no surgical) features unless or until the pleura is invaded.

The second type of aerobic pulmonary abscess is, by contrast, a lesion of substantial proportions. It occupies much or all of the bronchopulmonary segment which had been involved in the antecedent necrosuppurative bronchopneumonic process, and we therefore term the lesion a "segmental" abscess of the lung. It is with this type of lesion alone that we are concerned henceforth. The subject of acute segmental pulmonary abscess will be taken up from the standpoints of pathology, symptomatology, physical signs, diagnosis, and therapy.

I. *Pathology*.—From the viewpoint of pathology, there are a number of features which resemble closely and some which are quite dissimilar from those of acute putrid abscess of the lung. Perhaps the most striking difference lies in the strict localization of a putrid abscess to one part of the lung in the great majority of cases; whereas, a nonputrid abscess may exist in one bronchopulmonary segment, simultaneously with areas of necrosuppurative bronchopneumonia elsewhere in the lung. In other cases, multiple nonputrid abscesses may be present in several parts of the lung on one side, or on both sides, and at the same time areas of necrosuppurative bronchopneumonia exist in still other parts. Another contrast is to be seen in the extent of the infection of the parenchyma about the abscess. A putrid abscess of the lung begins as a localized area of gangrenous bronchopneumonia and the lesion, by the time it is recognizable clinically, usually is a well-defined abscess surrounded by a limited area of pneumonitis. By contrast, the nonputrid abscess throughout most of the clinical course may be, and often is, situated in the midst of extensive necrosuppurative bronchopneumonia. Thus, despite close resemblance between the two varieties in some instances, each presents distinctive features which warrant separate classification and consideration.

The statements to be made in regard to the gross pathology of nonputrid pulmonary abscess are based largely on observations made at operation combined with studies of roentgen features. We have designated as pulmonary abscesses all lesions in which collections of pus of substantial proportions existed within the substance of the lung, regardless of the presence or absence of adjacent bronchopneumonia. We also have termed "acute" all pulmonary abscesses of less than six weeks' duration.

The interpretation of the pathology of scattered pulmonary abscesses is based essentially upon roentgen films and occasional autopsies, for patients with such lesions rarely have been subjected to surgical treatment. These lesions are similar, pathologically, with soli-

frequently by profuse sweats. The sputum is frankly purulent and often copious. It is usually of greenish or grayish tinge and is either entirely free from odor or has a faintly musty smell. Severe pain in the chest at the onset and hemoptysis when the expectoration of pus begins, are occasional features. These are not present uniformly, as in the case of putrid pulmonary abscess. The degree of dyspnea and of prostration varies considerably.

The characteristic roentgen film in cases of necrosuppurative bronchopneumonia discloses an area of pneumonic infiltration involving a substantial portion of a lobe, the density of the shadow usually being greater than that seen in the nonsuppurative type of bronchopneumonia. The film may disclose a single lesion, multiple (discrete or coalescing) lesions in one lobe, involvement of more than one lobe, bilaterally situated lesions, or other bizarre combinations. The pathognomonic roentgen sign of necrosuppurative bronchopneumonia is rarefaction within the area of pneumonic infiltration. This may occur in the form of one or more circular areas of diminished density, as a single zone or as multiple ill-defined lighter zones situated within the area of consolidation. It is not seen in all cases and differences of opinion arise, not infrequently, in the interpretation of questionable areas of rarefaction. When a fluid level is seen, the formation of an abscess may be assumed to have begun.

The physical signs are essentially those of nonsuppurative bronchopneumonia, but the percussion note over the area or areas of dullness is apt to be more flat. At times, areas of involvement disclosed by x-ray examination may not be detected by the customary physical examination.

The clinical course of necrosuppurative bronchopneumonia is not predictable. It ranges from a short-lived infection ending in early recovery to a fatal form characterized by prolonged fever, profuse purulent expectoration, and spread of the pulmonary infection.

It is evident from all of the foregoing that the stage at which necrosuppurative bronchopneumonia becomes pulmonary abscess cannot be defined precisely. Thus, on the basis of a number of observations, we note that apparent transformation may take place rapidly or gradually and may occur at any period in the course of the disease. A transitional stage undoubtedly exists, but, since it cannot be identified by any available diagnostic method, it will not be included in the consideration of pulmonary abscess which now follows.

C. AEROBIC PULMONARY ABSCESS

Aerobic abscess of the lung occurs in two forms, "interstitial" and "segmental." Interstitial abscess has been discussed in another communication.² Again we point out, however, that interstitial abscesses

(1) are usually much smaller than the segmental variety, (2) usually are multiple, (3) may lie superficially or deeply in the lung, (4) are of varied etiology, and (5) ordinarily present no clinical (and no surgical) features unless or until the pleura is invaded.

The second type of aerobic pulmonary abscess is, by contrast, a lesion of substantial proportions. It occupies much or all of the bronchopulmonary segment which had been involved in the antecedent necrosuppurative bronchopneumonic process, and we therefore term the lesion a "segmental" abscess of the lung. It is with this type of lesion alone that we are concerned henceforth. The subject of acute segmental pulmonary abscess will be taken up from the standpoints of pathology, symptomatology, physical signs, diagnosis, and therapy.

I. *Pathology*.—From the viewpoint of pathology, there are a number of features which resemble closely and some which are quite dissimilar from those of acute putrid abscess of the lung. Perhaps the most striking difference lies in the strict localization of a putrid abscess to one part of the lung in the great majority of cases; whereas, a nonputrid abscess may exist in one bronchopulmonary segment, simultaneously with areas of necrosuppurative bronchopneumonia elsewhere in the lung. In other cases, multiple nonputrid abscesses may be present in several parts of the lung on one side, or on both sides, and at the same time areas of necrosuppurative bronchopneumonia exist in still other parts. Another contrast is to be seen in the extent of the infection of the parenchyma about the abscess. A putrid abscess of the lung begins as a localized area of gangrenous bronchopneumonia and the lesion, by the time it is recognizable clinically, usually is a well-defined abscess surrounded by a limited area of pneumonitis. By contrast, the nonputrid abscess throughout most of the clinical course may be, and often is, situated in the midst of extensive necrosuppurative bronchopneumonia. Thus, despite close resemblance between the two varieties in some instances, each presents distinctive features which warrant separate classification and consideration.

The statements to be made in regard to the gross pathology of nonputrid pulmonary abscess are based largely on observations made at operation combined with studies of roentgen features. We have designated as pulmonary abscesses all lesions in which collections of pus of substantial proportions existed within the substance of the lung, regardless of the presence or absence of adjacent bronchopneumonia. We also have termed "acute" all pulmonary abscesses of less than six weeks' duration.

The interpretation of the pathology of segmental pulmonary abscesses is based essentially upon roentgen films and occasional multiple biopsies, for patients with such lesions rarely have been subjected to surgical treatment. These lesions are similar, pathologically, to the

tary pulmonary abscess which will be considered directly. However, the abscesses usually are small (although occasionally they attain large size), and the enveloping infiltration generally is rather limited. Invasion of the pleura is rare, and when it occurs the resulting pyopneumothorax almost invariably is encapsulated. Except when a complicating pleural infection exists, the scattered variety of aerobic pulmonary abscess is not a surgical lesion and will receive no further consideration.

There are at least three varieties of "segmental" acute aerobic abscess which, from a surgical viewpoint, merit consideration: (1) pulmonary abscess in the midst of, and apparently an incidental part of, an extensive necrosuppurative bronchopneumonia; (2) pulmonary abscess as the prominent or predominating lesion, but surrounded by a considerable area of necrosuppurative bronchopneumonia; (3) typical pulmonary abscess with a more or less sharply limited and narrow surrounding zone of infected lung.

Certain features are common to all three varieties. As already stated, the abscess is of substantial proportions, the range in diameter being from two to four inches or even more. The collection of pus is essentially monolocular, although recesses may be present. An important feature (as noted in all operative cases) is the extension of the abscess to, or almost to, the surface of the lung. This is to be anticipated, since a bronchopulmonary segment is involved. Overlying adhesions, agglutinating the apposed visceral and parietal pleurae, were found at operation in all cases. They usually were more edematous and less dense than in putrid pulmonary abscess, but sufficed in each instance for safe operative entry of the abscess in one stage. In the typical case the shell of lung between the abscess and the sealed-off pleurae is thin and practically avascular; in other instances, it is thicker and more vascular. The contents of the abscess vary from a considerable amount of pus under tension to air coexisting with relatively small quantities of pus. In cases of widespread excavation the outstanding characteristic is extensive destruction of bronchi. As a result, many bronchial orifices of varied size are to be seen at widely scattered points in the wall of the abscess. They generally are situated in recesses between fleshy ridges that rise from the floor and walls of the cavity. In other words, the interior of the cavity often presents the typical picture of fully developed "lattice lung" even when the lesion, from the viewpoint of duration, is as yet only in the acute stage. This picture is to be contrasted with the few bronchial orifices often existing at operation in cases of acute putrid abscess of the lung.

The surgical pathology of pulmonary abscess which perforates into the pleural cavity is worthy of special emphasis because of thera-

peutic implications. We do not refer here to the small cortical type (interstitial abscess) to which reference already has been made, but to "segmental" abscess. In the latter, expectoration of pus continues after rupture into the pleura has occurred, if the perforation does not permit of complete evacuation of the pulmonary abscess into the pleural space. Furthermore, the perforation may take place near the uppermost portion of the abscess and thus drainage into the pleura may be inadequate. The following three features of the pathology of perforation are of special surgical significance: (1) The perforation may be of insignificant size and covered by slough. (2) It may be so situated as to be difficult of detection; that is, in the re-entrant angle between visceral and parietal pleura, or on a ridge separating two unequal parts of a bilocular empyema, etc. (3) There may be two or more widely separated perforations resulting in two or more non-communicating empyemas.

II. *Clinical Manifestations.*—The symptomatology and physical signs of pulmonary abscess do not require extended discussion for they present few, if any, distinctive features. In general, the symptoms are indistinguishable from those of the pre- or coexisting bronchopneumonia. Occasionally, purulent expectoration may increase in amount, and fever may assume a more distinctly remittent character coincident with the development of a more definitely septic state. The physical signs of bronchopneumonia (q.s.) persist, rarely with the addition of signs of cavitation. The symptoms and physical signs of perforation into the pleura, with the formation of empyema, usually are not distinctive.

III. *Röntgenographic Features.*—Because of the paucity of physical signs and symptoms, the diagnosis of aerobic abscess of the lung must be based essentially on roentgenographic features. As already pointed out, in necrosuppurative bronchopneumonia a stage may be reached in which a number of more or less distinct areas of rarefaction, seen in the film, become well-defined cavities containing fluid levels. At this stage, localization of the suppurative process can be assumed to have occurred and an abscess of the lung therefore can be said to exist. In typical cases the fluid level becomes longer and the area of rarefaction (pulmonary excavation) larger. Multiple fluid levels not infrequently are seen within the zone of pulmonary infiltration. In other cases, the pulmonary cavity appears empty except for a small fluid level at its most dependent portion. A fluid level, pathognomonic of pulmonary abscess, was present at some stage of the disease in all of our cases in which the diagnosis was verified by operation. This is in contrast with the findings in certain cases of putrid pulmonary abscess in which no fluid levels were visible in the films.

An effort should be made to distinguish between the fluid levels of pulmonary abscess and those of pyopneumothorax. The extent of the fluid levels is of little value for this purpose, although the larger levels are more likely to be those of pyopneumothorax. On occasions, intra- and extrapulmonary fluid levels coexist in one film, and under such circumstances the difference between them is more readily recognizable. There are two roentgen features which characterize, and usually are to be noted in, the presence of pyopneumothorax. First, at fluoroscopic examination, the fluid level usually is much more mobile than that of pulmonary abscess. Secondly, in the postero-anterior view, the fluid level often extends to the thoracic cage, there being no lung intervening. Errors in diagnosis may occur, however, in spite of every effort to differentiate between perforated and unperforated pulmonary abscess. In our experience the error usually has been to make the diagnosis of pyopneumothorax while the lesion was still situated entirely within the substance of the lung.

In addition to the occurrence of a fluid level on the film, the change from bronchopneumonia to pulmonary abscess often is to be recognized by alterations within the area of pulmonary infiltration. As already pointed out, the infiltration due to bronchopneumonia is seen as a dense more or less homogeneous shadow. It is appreciably less dense and more broken up (mottled) in pulmonary abscess. When widespread pulmonary excavation occurs, much of the shadow is replaced by a single large area of rarefaction.

The discussion of the roentgen features of aerobic pulmonary abscess cannot be concluded without calling attention to the fact that, even when the pulmonary abscess is fully developed, one or more areas of bronchopneumonia may exist elsewhere in the lung. This fact is stressed because we, like others, occasionally have overlooked a small but tell-tale bronchopneumonic patch as a result of focusing attention on the obvious lesion.

IV. Differential Diagnosis.—A detailed analysis of the differential diagnosis of aerobic pulmonary abscess and other lesions which may simulate it would lead too far afield. However, brief reference should be made to several diseases which present similar features. Aerobic abscess is perhaps most often confused with pulmonary tuberculosis, since the resemblance between the two, both in clinical course and in roentgenological aspects, may be very close. Indeed, one of our first operative cases of aerobic pulmonary abscess was regarded for a time as a case of pulmonary tuberculosis. When doubt exists, the diagnosis of pulmonary abscess should be based upon the continued absence of tubercle bacilli from the sputum together with the persistence of profuse purulent expectoration. The differentiation should not be

difficult if films made at intervals over a period of several weeks are available. In occasional instances, bronchoscopy may be required. The latter is necessary more often, however, in order to distinguish between pulmonary abscess and pulmonary suppuration secondary to bronchial neoplasm. A number of cases have come under our observation in which the latter diagnosis was entertained because of cough, fever, emaciation, clubbed fingers, and a roentgen film disclosing dense pulmonary infiltration. Bronchoscopic examination established the diagnosis in these cases without difficulty. It also has proved invaluable in differentiating between putrid and nonputrid pulmonary abscess. As we have pointed out elsewhere,³ putrid abscess is not always characterized by foul odor of the sputum. When the bronchus communicating with such an abscess is shut off by edema, expectoration may be purulent because of the associated bronchitis, and yet be completely free of odor. In addition, the roentgen films of putrid and nonputrid abscess may be identical. Under the foregoing circumstances, the two diseases may be indistinguishable until foul odor or foul pus is detected at bronchoscopy. In children the diagnosis of aerobic pulmonary abscess offers no difficulty, except in cases requiring differentiation from putrid abscess or from aspirated foreign body with secondary infection. Under such circumstances, bronchoscopic examination usually will establish the correct diagnosis.

V. *Preoperative Localization*.—We believe that accurate localization of the pulmonary abscess is the cornerstone of correct operative treatment, and some remarks on this subject are therefore in order. Since percussion and auscultation do not locate the lesion with precision, accurate localization is practically synonymous with roentgenographic localization. The roentgen films must be studied with the particular object of determining the site at which the pulmonary abscess is situated closest to the surface of the lung. (As has already been pointed out, agglutinating adhesions between the visceral and parietal pleura exist in that area.) Posteroanterior, lateral, and, at times, oblique pictures should be taken for this purpose, and fluoroscopy also is to be employed. With rare exceptions, bedside films are of very limited value for precise localization. The most favorable and perhaps the only site for safe surgical approach to the pulmonary abscess is a point directly over the fluid level. Here the abscess can be assumed to be nearest the visceral pleura. Ribs should be counted therefore with painstaking care, in order to be sure that the correct one will be resected at the time of operation. One should attempt also to determine with care the site at which the segment is to be removed from the chosen rib. If radio-opaque skin markers are employed during roentgenography, due allowance should be made for the shift of the overlying soft parts when the arm is placed in the appropriate position on the operating table. In short, every effort should be made to deter-

mine the precise situation of the most superficial portion of the pulmonary abscess, in order to approach the lesion safely through agglutinating visceroparietal pleural adhesions.

VI. *Operative Indications.*—The problem of operative indications now will be discussed. It should be stated at once that we are still in doubt in regard to a number of aspects of this question. In comparison with acute putrid abscess of the lung, the indications for operation in nonputrid (aerobic) abscess are less precise and clear-cut. The reasons are fairly obvious. A putrid abscess is a well encapsulated lesion; a nonputrid abscess not infrequently consists of a collection of pus in the midst of an active bronchopneumonia. Because of this difference, abrupt cessation of symptoms is the rule after operation for putrid abscess; whereas, little, if any, immediate result is apt to be noted after operation in some cases of nonputrid abscess (see case reports). Another reason for uncertainty in formulating the operative indications in cases of aerobic abscess is the ever present possibility of spontaneous recession of even large and extensively excavated lesions, particularly in children. Thus, a more conservative attitude toward operative treatment for nonputrid abscess than for putrid abscess is warranted.

The three forms of aerobic suppuration which were described in a preceding paragraph should be restated at this point, because they have a direct bearing on operative indications: (1) unencapsulated pus in the midst of necrosuppurative bronchopneumonia; (2) more or less circumscribed pulmonary abscess in the midst of necrosuppurative bronchopneumonia; (3) true encapsulated abscess. The last comprises the sole lesion for which operative treatment may be indicated. A source of difficulty, in our experience up to the present time, is the fact that this form is not always to be distinguished from the first and more particularly from the second form of suppuration. A true pulmonary abscess can be recognized with ease when the roentgen film is typical, for there exists a cavity with fluid level which is well demarcated from the adjacent lung by a narrow rim of infiltration. Unfortunately, this surgically remediable variety may be roentgenologically indistinguishable from the others when the cavity is more or less full and coexisting dense pleural reaction obscures the pulmonary lesion. Thus, we have operated in error in a few instances in which pus in the midst of bronchopneumonia and not a true pulmonary abscess existed. Although operation had no significantly untoward effect in these cases, the latter should not be subjected to operation if they can be recognized.

An important operative indication in pulmonary abscess is the imminence of or the actual presence of perforation into the pleura. In cases of obvious pleural invasion, the diagnosis usually can be made on the basis of physical signs and especially of roentgen film. How-

ever, the diagnosis of empyema may prove to be incorrect even when the percussion note is flat, the breath sounds distant, and a dense homogeneous shadow is present in the film. Indeed, the diagnosis may be incorrect even when aspiration reveals pus. Thus, we have operated for supposed empyema several times, only to find collections of pus confined to the lung. All proved to be cases in which multiple collections of pus existed in the midst of extensive bronchopneumonia, and accordingly operation was without appreciable beneficial effect.

In general there are three indications for operation in true pulmonary abscess: (1) to terminate a septic course which may prove fatal, as a result of further extension of suppuration or of spillover to other parts of the lung; (2) to prevent the development of empyema, when perforation of the lesion into the pleura seems imminent; (3) to drain the pleural collection, and to establish better drainage of a perforated lung abscess in cases of pyopneumothorax when the perforation is small. An indication for imperative operation seems to exist in all three of the above groups. Strictly speaking, however, it exists only in the third group and even then only insofar as the pleural infection is concerned. Spontaneous recovery might have ensued in some of the cases in the first group upon which we have operated. The following case is cited as an example of an entirely unexpected spontaneous recovery and illustrates that the clinical course may change with dramatic suddenness in this surprising disease.

W. K., Queens General Hospital, No. 32,274, a male, 39 years old, had been acutely ill for a period of three weeks suffering from pain in the right chest, high fever, and profuse purulent expectoration of pus. On admission to the hospital, extensive infiltration within the right lower lobe was demonstrated by roentgenography. At the end of two months, a large abscess developed in the right lower lobe. When an additional abscess, with fluid level, appeared in an adjacent part of the lobe and the patient's condition grew worse, surgical consultation was requested. The impression gained was that one or both of the abscesses already had perforated into the pleura. A large transfusion was given preparatory to operation. A roentgenogram taken on the day before that of the proposed operation revealed almost complete disappearance of the fluid levels and, accordingly, operation was deferred. The pulmonary lesions cleared rapidly thereafter. Follow-up roentgenograms demonstrate complete disappearance of pulmonary infiltration and the patient has remained well.

A strong argument in favor of operative treatment of true acute aerobic pulmonary abscess is the uniformly satisfactory outcome of operation. Thus, there has been no operative mortality, little post-operative morbidity, and complete cure in all such cases.

We are in doubt, at the present time, as to the procedure to be followed when a pulmonary abscess and one or more areas of bronchopneumonia coexist. The development of bronchopneumonia at a distance from the pulmonary abscess has been observed in several of our

cases. Such areas of bronchopneumonia may be assumed to be of spillover origin. Accordingly, their very presence may be considered an argument in favor of operation for the purpose of avoiding additional spillover lesions. On the other hand, the existing bronchopneumonia may continue to spread after drainage of the pulmonary abscess. The decision to operate must be based, therefore, on the manifestations in individual cases, but we may state that in general we do not favor operation in the presence of bronchopneumonia of appreciable extent. The same holds true for cases in which two or more pulmonary abscesses exist, for we have operated on a few of these cases and have found that operation did not materially influence the clinical course.

VII. *The Operation.*—Before discussing the technique of the one-stage operation, we repeat our statement concerning the necessity of accurate localization of the abscess. Indeed, we believe that correct surgical approach, which involves entry of the most superficial portion of the abscess through overlying visceroparietal adhesions, is even more important in the case of aerobic than in anaerobic (putrid) abscess. Accordingly, operation should not be performed unless careful roentgenologic study and accurate localization have been carried out. The technique of operation should be, in our opinion, essentially the same as that which we have described for putrid pulmonary abscess.⁴ Details therefore will be omitted and only a number of general principles stated. Local anesthesia usually is employed. The incision is placed directly over the abscess, regardless of its location, for there should be no routine incision or favorite site of drainage. Excision of a limited section (two to three inches) of a single rib usually suffices. Edematous visceroparietal pleural adhesions are exposed. They are incised over a small area down to the inflamed lung and are carefully inspected in order to ascertain that the free pleural cavity is completely sealed off within the field. A dry operative field is essential. If the operative exposure is placed at the correct site, aspiration through a thin shell of lung will immediately reveal air, or pus, or both. A specially designed, cutting grooved-director and scissors⁵ then are employed to split open the shell of infiltrated lung which comprises the roof of the abscess cavity. In view of the type of infection which exists, as complete an unroofing as in the case of putrid abscess is not necessary. Malleable retractors are inserted, the cavity is sucked dry, and recesses are sought with the aid of direct illumination. If a narrow communication exists between an additional locule and the parent cavity, it is widened by careful sharp dissection. At the termination of operation, the abscess cavity, and any recesses which may exist, are packed snugly to their limits.

The operative treatment of pyopneumothorax, secondary to perforated pulmonary abscess, consists primarily in adequate drainage of

the pleural collection or collections of pus. Special consideration should be given to, and emphasis placed upon, the question of management of the coexisting perforated pulmonary abscess because of the clinical importance of the latter. In the discussion of the surgical pathology of perforated abscess of the lung, attention was called to several features which we have found to be of therapeutic significance as well as of general interest. These have a direct bearing upon the technique of operation. If a pulmonary abscess of substantial proportions characterized by the free expectoration of purulent sputum perforates into the pleural cavity, such perforation may be regarded provisionally as having resulted in adequate drainage if expectoration ceases. If expectoration continues, however, inadequate drainage can be assumed. There can be no difference of opinion up to this point. At the present time, the generally-accepted plan in cases of perforated pulmonary abscess appears to be to limit the operative procedure strictly to drainage of the pleural infection, regardless of the status of the pulmonary abscess. This seems to be based upon the assumption that a pulmonary abscess will heal if perforation into the pleura has occurred. We have observed a number of cases which illustrate the fallacy of this view (see Case 12). It is our opinion that an inadequately draining, perforated pulmonary abscess requires attention at the time of operation on the pyopneumothorax if the patient's condition will permit any procedure beyond emergency pleural drainage. If the latter constitutes the sole measure that can be carried out safely, drainage of the pulmonary abscess should be performed as soon as possible thereafter. The point we wish to stress is that an inadequately draining pulmonary abscess may present a trying as well as an unsatisfactory problem, if its operative treatment is too long deferred. (Cases will be cited to illustrate the contrast between the results of early and late drainage.) The technique of immediate drainage of a perforated pulmonary abscess obviously is simpler than of an unperforated abscess. The sole difficulty may consist in locating the site of perforation. As indicated in our discussion of the pathology of perforated pulmonary abscess, the site of perforation at times may be seen readily, or may have to be sought assiduously. In occasional instances two or more perforations may exist. After the perforation is found, the procedure on the pulmonary abscess is limited to simple crucial incision through its roof, at the site of perforation, followed by packing of the pulmonary cavity.

VIII. Postoperative Course and Treatment.—The postoperative course of cases of unperforated abscess of the lung usually is smooth if the pulmonary abscess is the sole lesion; and stormy if there is associated necrosuppurative bronchopneumonia. The existence of the latter is indicated by continuing cough, purulent expectoration, and

fever. Distant areas of bronchopneumonia also may be the source of these manifestations. The point to be stressed is that, in contrast to cases of putrid abscess of the lung, untoward postoperative manifestations often may be referable to the underlying disease (necrosuppurative bronchopneumonia) rather than to complications in the operative field. The management of the wound usually is simple. Packings are removed when they are loose (ordinarily in a week's time) and are replaced in order to prevent premature closure of the cavity. At each succeeding dressing the cavity is packed lightly, until it has become obliterated completely. The superficial wound then is permitted to heal.

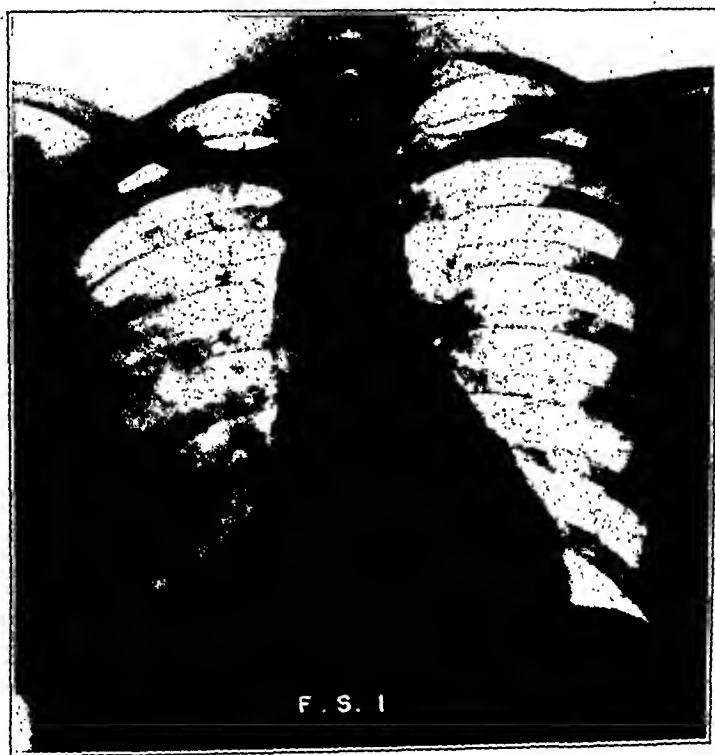


Fig. 2.—F. S. Necrosuppurative bronchopneumonia of right lower lobe. Note multiple areas of rarefaction. This type of lesion characteristically precedes aerobic pulmonary abscess.

A "lattice lung" may be the sequel when numerous bronchial fistulae are present in a large smooth-lined cavity and is apt to remain chronic. As pointed out elsewhere,⁶ free grafts of fat have been transplanted successfully for the obliteration of pulmonary cavities even in the early postoperative period. Regardless of the method that is chosen, every effort at closure of the pulmonary cavity should be made as soon as the infection has cleared up.

IX. Results of Treatment.—The results of operation for pulmonary abscess can be indicated most readily by dividing the cases into groups

in accordance with special features of the pathologic process. Although many variations of the latter have been indicated already, for purposes of presentation the cases will be divided into only a few general groups. Illustrative cases, selected from each group, will demonstrate the problems which have been encountered and the results that have been obtained. Interest, from a surgical viewpoint, attaches chiefly to the results in the first group, and most of the operative cases in this group therefore will be reported. Only a few illustrative cases from each of the other groups will be reported.

Group I. Acute Pulmonary Abscess.—All cases were operated upon within six weeks of the onset of pulmonary manifestations, the ma-

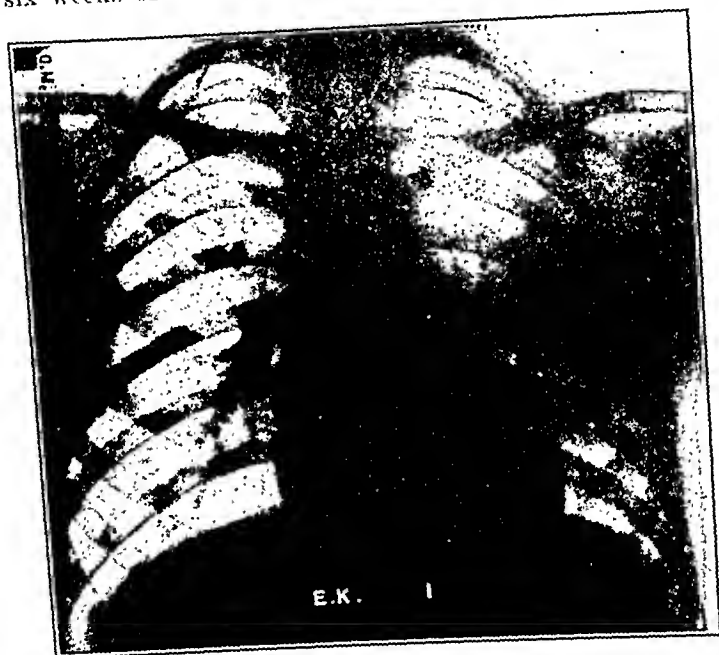


Fig. 3.—E. K. Necrosuppurative bronchopneumonia in left upper lobe. Note density of pulmonary infiltration.

jority being operated upon in the second and third weeks. All are well, the follow-up period ranging from one to several years.

CASE 1.—M. R., female (Hospital No. 386,380), 20 years old, admitted November, 1935, was ill for eleven days prior to admission with chills, fever, cough, expectoration of pus, and severe toxemia. The roentgenogram disclosed a large cavity, with fluid level, in the left upper lobe. The patient became worse during ten days of hospital observation, with increasing amounts of sputum and roentgenologic evidence of increase in the size of the lesion. Bronchoscopy was performed because of doubt between the diagnosis of shut-off putrid abscess and that of tuberculous cavitation. It revealed nonfetid pus issuing from the left upper lobe bronchus. The diagnosis of aerobic pulmonary abscess having been made, operation was decided upon because the clinical course obviously was unsatisfactory. At operation, an abscess in the

fever. Distant areas of bronchopneumonia also may be the source of these manifestations. The point to be stressed is that, in contrast to cases of putrid abscess of the lung, untoward postoperative manifestations often may be referable to the underlying disease (necrosuppurative bronchopneumonia) rather than to complications in the operative field. The management of the wound usually is simple. Packings are removed when they are loose (ordinarily in a week's time) and are replaced in order to prevent premature closure of the cavity. At each succeeding dressing the cavity is packed lightly, until it has become obliterated completely. The superficial wound then is permitted to heal.

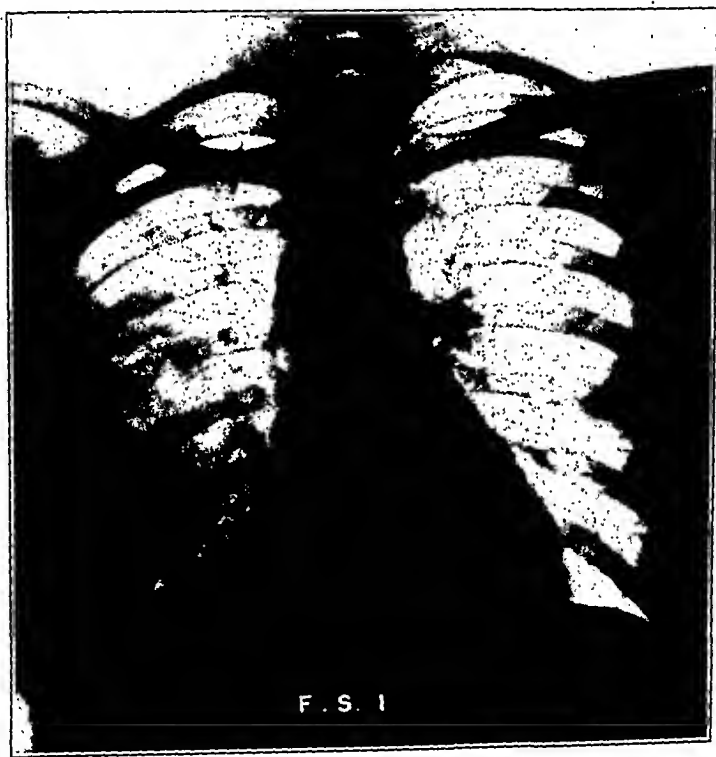


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IX. *Results of Treatment.*—The results of operation for pulmonary abscess can be indicated most readily by dividing the cases into groups

An enormous pulmonary cavity was encountered. It occupied much, if not most, of the lower lobe, was smooth-lined, partly empty, and presented many large and small bronchial orifices situated on and between fleshy ridges. Communicating with this main cavity was a small abscess situated within the lobe just above the diaphragm. The bridge between the two was enlarged by sharp dissection, pus in the smaller abscess was removed by suction, and both cavities were packed.

The patient was afebrile within three days of operation and remained so. There was prompt cessation of cough and expectoration, and rapid improvement in general condition. The pulmonary cavity quickly became clean. It soon assumed the appearance characteristic of lattice lung. Because of a distinct tendency towards healing, the skin was permitted to close. The patient was symptom-free, but x-ray films demonstrated persistence of the cavity. Accordingly, the wound was reopened



Fig. 5.—E. K. Lateral view, filmed at same time as Fig. 4. The abscess is situated in the axillary portion of upper lobe close to the fissure. An analysis of Figs. 4 and 5 offers a precise localization of the lesion.

about two months after the original operation and a free graft of fat was introduced.⁶ The patient has remained well and the cavity is closed.

CASE 3.—A. S., male (Hospital No. 405,565), 13 years old, admitted March, 1937, with a history of eleven days' severe illness. In the beginning, meningitis was suspected. Pneumonia of the right lung was diagnosed on the third day; cough and expectoration of pus began soon thereafter. Expectoration of pus in increasing amounts led to the suspicion of a pulmonary abscess. The diagnosis of pyopneumothorax was made on the preadmission x-ray films. Fever was high and septic, and the patient was critically ill throughout the eleven days.

Films taken on admission to the hospital indicated a large abscess, with fluid level, situated in the posterior part of the right upper lobe and confined to the lung. Operation was performed on the day of admission. Adherent, inflamed lung was exposed by the excision of a short section of one rib. Aspiration through a thin

upper lobe, situated adjacent to the interlobar fissure, was unroofed and packed. Fever, as well as some purulent expectoration, continued for three weeks after operation due to an area of neerosuppurative bronchopneumonia in the opposite lung. This fact was established by bronchoscopy and by x-ray. The wound remained in good condition. Postoperative bronchoscopy, performed in order to determine if retention of pns in the operative field was the cause of continuing fever, was essentially negative. Convalescence was slow. A bronchial fistula was present in the depths of the wound for several weeks after operation. It was permitted to close after x-ray films of the chest revealed that pulmonary infiltration was subsiding. The wound has remained healed; the patient is symptom-free; x-ray of the chest is negative.

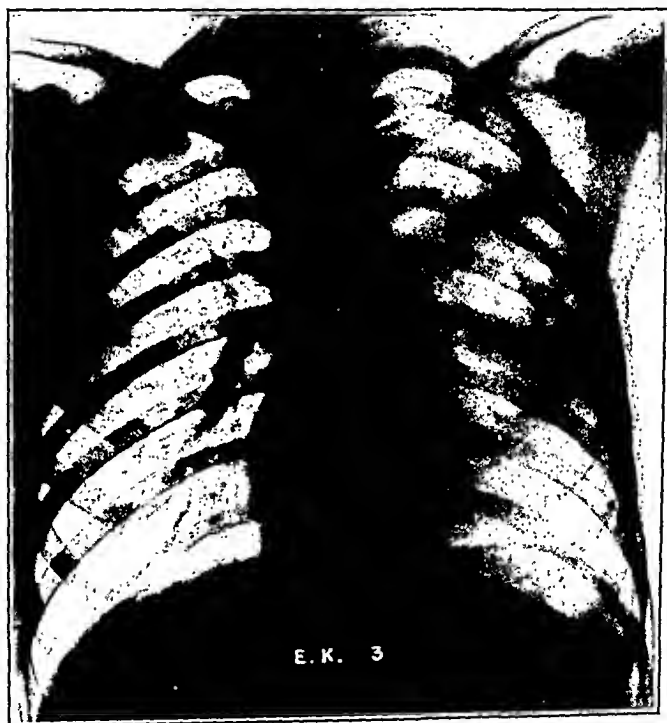


Fig. 4.—E. K. Same case as shown in Fig. 3, several days later. Typical abscess replacing area of pulmonary infiltration. There should be noted the long fluid level suggesting pyopneumothorax as well as the limited surrounding infiltration.

CASE 2.—S. W., male (Hospital No. 394,118), 12 years old, admitted April, 1936, was ill with "pneumonia" for four weeks before admission. There were fever, expectoration of moderate amounts of thick pus, and, in the roentgenogram, a dense, homogeneous shadow occupying the region of the right lower lobe. A few days before admission, a large amount of pus suddenly was expectorated. The x-ray film then revealed a giant cavity with fluid level. There was a difference of opinion as to whether the lesion was confined to the lung or had perforated into pleura. Operation was performed shortly after admission because the septic course had continued despite partial evacuation of the abscess by way of the bronchial tree. At operation, a thin shell of avascular lung was traversed through well-defined pleural adhesions.

An enormous pulmonary cavity was encountered. It occupied much, if not most, of the lower lobe, was smooth-lined, partly empty, and presented many large and small bronchial orifices situated on and between fleshy ridges. Communicating with this main cavity was a small abscess situated within the lobe just above the diaphragm. The bridge between the two was enlarged by sharp dissection, pus in the smaller abscess was removed by suction, and both cavities were packed.

The patient was afebrile within three days of operation and remained so. There was prompt cessation of cough and expectoration, and rapid improvement in general condition. The pulmonary cavity quickly became clean. It soon assumed the appearance characteristic of lattice lung. Because of a distinct tendency towards healing, the skin was permitted to close. The patient was symptom-free, but x-ray films demonstrated persistence of the cavity. Accordingly, the wound was reopened



Fig. 5.—E. K. Lateral view, filmed at same time as Fig. 4. The abscess is situated in the axillary portion of upper lobe close to the fissure. An analysis of Figs. 4 and 5 offers a precise localization of the lesion.

about two months after the original operation and a free graft of fat was introduced.⁶ The patient has remained well and the cavity is closed.

CASE 3.—A. S., male (Hospital No. 405,565), 13 years old, admitted March, 1937, with a history of eleven days' severe illness. In the beginning, meningitis was suspected. Pneumonia of the right lung was diagnosed on the third day; cough and expectoration of pus began soon thereafter. Expectoration of pus in increasing amounts led to the suspicion of a pulmonary abscess. The diagnosis of pyopneumothorax was made on the preadmission x-ray films. Fever was high and septic, and the patient was critically ill throughout the eleven days.

Films taken on admission to the hospital indicated a large abscess, with fluid level, situated in the posterior part of the right upper lobe and confined to the lung. Operation was performed on the day of admission. Adherent, inflamed lung was exposed by the excision of a short section of one rib. Aspiration through a thin

layer of lung revealed pus and air. The abscess was unroofed by a rather liberal excision of the overlying avascular shell of lung (no more than one-fourth of an inch in thickness). The pus was evacuated by suction, the cavity found to be monolocular with several moderate-sized bronchial fistulas. The cavity was packed with gauze.

The postoperative course was entirely smooth at first, with prompt disappearance of cough and expectoration and subsidence of fever. Later, however, there was recrudescence of fever without cough. The roentgen film revealed pulmonary infiltration adjacent to the abscess cavity and distinct widening of the mediastinum. One week later, a film disclosed subsidence of this newly developed infection, and subsequent films demonstrated the complete disappearance of pulmonary infiltration and of evidences of mediastinitis. The wound always was in satisfactory condition, and quickly contracted about the tube leading to the region of the bronchial fistula. The tube was removed when the x-ray films indicated the pulmonary condition to be satisfactory, and the wound then healed promptly. The patient has remained symptom-free.

CASE 4.—E. K., male (Hospital No. 390,519), 13 years old, was ill for nine days before admission in March, 1936. At the onset the diagnosis of left upper lobe pneumonia was made and was confirmed by a film disclosing a dense shadow occupying about half of the upper lobe. Pain in the chest was a prominent feature. Expectoration of pus began four days after the onset, and rather large amounts were brought up each day. The level of fever was lower after the first week. X-ray films taken two days before admission revealed a large cavity occupying much of the site of the pre-existing pulmonary infiltration. On hospital admission, films showed an increase in the size of the cavity and suggested that perforation into the interlobar fissure had occurred. The assumption of perforation was the indication for prompt operation. The operation, carried out through a surgical approach in the left axilla, consisted in the removal of a short section of one rib, disclosing agglutinating visceroparietal pleural adhesions, and the entry of a large cavity in the upper lobe through these adhesions. The overlying thin shell of lung was excised and the interior of the cavity inspected. Several small bronchial fistulas were noted. Although actual perforation into the interlobar fissure had not occurred, the adjacent lower lobe could be seen through the floor of the abscess cavity and perforation undoubtedly was imminent.

Clinically, the postoperative course was smooth and entirely uneventful. There was prompt cessation of cough and expectoration. However, the postoperative film showed pneumonic spread about the abscess cavity, which soon subsided. Early closure of the wound was permitted because the postoperative bronchial fistula was small.

The patient was well until a year and a half after operation (December, 1937), at which time he contracted a right upper lobe pneumonia. A roentgen film revealed areas of rarefaction in the midst of pneumonic infiltration and the diagnosis of a necrosuppurative bronchopneumonia was made. Spontaneous subsidence occurred. It was of interest to note that the left lung remained free from invasion. The patient has remained well since that time.

CASE 5.—B. D., male (Hospital No. 379,070), 18 months old, entered the hospital in April, 1935, with a history of upper respiratory infection, cough, fever, and convulsions of five days' duration. Roentgenography revealed a pleural effusion occupying the axillary portion of the right chest from base to apex. Aspiration yielded slightly turbid, yellowish fluid. Over a period of approximately two weeks, there was

little change to be seen in successive roentgenograms. The pleural fluid, which was aspirated several times, did not increase in amount. At the end of the two-week period, however, a film disclosed not only an increase in the pleural effusion but also two cavities, containing fluid levels, within the middle lobe. There was very little pulmonary infiltration about the cavities. At operation, a small amount of encapsulated turbid fluid was evacuated from the pleura and the abscesses in the middle lobe were evacuated, unroofed, and packed. Convalescence was uneventful. The patient has remained well.

The following case, which first came under our observation many months after operation for acute pulmonary abscess, is presented as an illustration of an unsatisfactory result after inadequate drainage.

CASE 6.—W. M., female (Hospital No. 417,402), 23 years old, was ill for five weeks with cough, purulent expectoration, and fever, at the time of her first operation elsewhere in June, 1937. In the preoperative film there was seen a multilocular lesion in the right lower lobe, with limited surrounding infiltration. This intrapulmonary collection of pus was drained through a small incision. Purulent expectoration continued, a second limited rib excision was performed at a somewhat higher level, and the pulmonary cavity was again entered and drained by a tube. Cough and purulent expectoration continued unchanged, and drainage from the pulmonary cavity continued. This was the status on admission to Mount Sinai Hospital where a chronic, multilocular abscess was liberally unroofed. Expectoration of pus subsided soon thereafter. The pulmonary lesion, however, was a chronic lattice lung which demonstrated no tendency to heal. It was too large and discharged too profusely to warrant an attempt at plastic closure. Accordingly, lobectomy was performed. After a long and trying postoperative period, the patient appeared convalescent for a time. Death occurred quite suddenly several months after operation apparently due to heart failure since no other cause was found at autopsy.

Group II. Subacute and Chronic Abscess.—These lesions are rare, because the antecedent acute abscess usually either subsides spontaneously, is fatal, or leads to pleural complications for which some operative procedure is performed. The following are the only two unperforated subacute or chronic aerobic abscesses which have come under our observation:

CASE 7.—B. L., male (Hospital No. 380,596), 42 years old, was first admitted in 1932 with a six years' history of recurring episodes of pain in the chest, cough, purulent expectoration, and transient fever. The original illness was said to have been a bronchopneumonia, and each of the episodes in succeeding years involved the same region of the lung. On admission, the roentgenogram revealed an abscess cavity in the axillary segment of the right upper lobe with little surrounding pulmonary infiltration. At the primary operation, a very stiff-walled pulmonary abscess about one and one-half inches in diameter was unroofed. There were no recurrences of the episodes of cough, fever, and chest pain, but profuse discharge from the cavity continued during the succeeding years. Secondary operations, for the purpose of establishing better drainage, were performed on two occasions, but did not result in improvement. Finally, resection of the upper lobe was performed three years after the original operation, for the purpose of eradicating the disease. This was followed by death from acute fibrinous (obstructive) bronchitis.

CASE 8.—L. H., male (Hospital No. 410,785), 52 years old, was admitted to the hospital in June, 1937, with a history of fever, cough, and profuse purulent expectoration of seven weeks' duration. Three days before admission, a large abscess developed in the soft parts over the right chest anteriorly. This was drained on admission. Roentgenography revealed an area of infiltration in the apex of the left lower lobe, which suggested the diagnosis of bronchial neoplasm with secondary pulmonary suppuration. Bronchoscopy, however, failed to reveal the presence of a bronchial neoplasm. There was no appreciable change in the successive roentgen films taken during a period of three weeks. At the end of that time, however, a

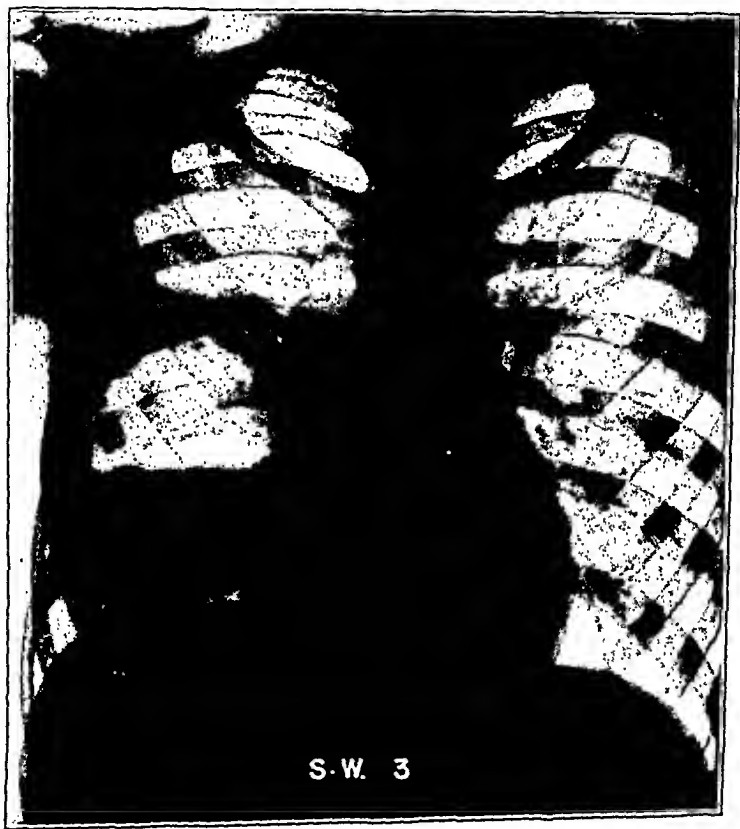


Fig. 6.—S. W. Enormous, typical pulmonary abscess confined to the right lower lobe. Limited surrounding pulmonary infiltration. Long fluid level strongly suggestive of pyopneumothorax.

large area of cavitation containing air and fluid appeared in the midst of the infiltrated area. At operation, a large unilocular nonputrid pulmonary abscess was evacuated, unroofed, and packed. Although the temperature became lower and cough and expectoration diminished, improvement was only temporary and subsequent films disclosed further extension of pulmonary infiltration. At the end of nine and one-half weeks, cavitation became visible within the infiltrated area; and at operation two large contiguous abscess cavities were evacuated, unroofed, and packed. Following this procedure, uneventful convalescence ensued. The patient has remained well.

Group III. Necrosuppurative Bronchopneumonia Complicated by Pulmonary Abscess.—Cases in this group are apt to go on to fatal termination, being uninfluenced by drainage of one or more pulmonary collections of pus. The latter usually are not definitely encapsulated. Empyema may be an added complication, and its drainage also is not likely to influence the clinical course favorably. Of this type of case, one example of an unperforated and one of a perforated lesion will be given.

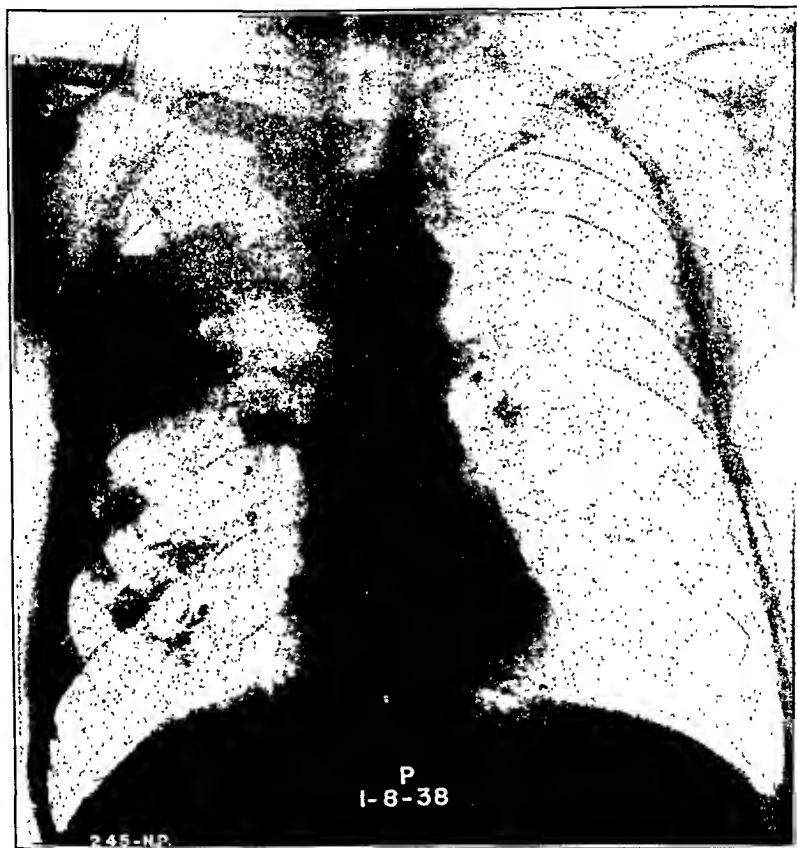


Fig. 7.—P. Large pulmonary abscess with localized pyopneumothorax. The overlapping fluid levels of each of these lesions is seen in the axillary portion of the dense homogeneous shadow.

CASE 9.—S. C., male (Hospital No. 417,451), 54 years old, was ill for seven weeks when admitted. The course throughout this period was characterized by irregular fever ranging to 104°, cough, profuse purulent expectoration, and evidence of toxemia. Roentgen films revealed large areas of infiltration in the right lower lobe, in two separate regions. Operation was performed on the diagnosis of perforated pulmonary abscesses with encapsulated empyemas. The lesions were approached through two separate incisions. At each site multilocular collections of pus were evacuated. They lay superficially within the substance of the lung and were entered

through well-defined pleural adhesions. There was no empyema. In each instance, the multiple collections of pus were not encapsulated and the adjacent lung obviously was the seat of an intense pneumonitis.

There was transient improvement for about two weeks, and then a return to the preoperative state. Death occurred about five weeks after operation due to spread of the infection throughout much of the right lung and part of the left.

CASE 10.—C. P., male (Hospital No. 418,725), 58 years old, was ill for two months before admission. The clinical course was very similar to that in the preceding case. An early film revealed dense infiltration in the right upper lobe; later films demonstrated areas of rarefaction within that shadow. He was operated upon shortly after admission on the diagnosis of perforated pulmonary abscess. An extensive multilocular suppurative process, involving much of the upper lobe, was encountered. Purulent tracts were found extending in various directions in the midst of intensely inflamed lung. There were two perforations which led to substantial collections of pus in the pleura.

Expectoration of pus diminished temporarily after operation and then recurred. Subsidence of fever and improvement in the general condition also were transient. Death occurred three weeks after operation from continuing pulmonary suppuration and cerebral infection. At autopsy, collections of pus adjacent and distant to those which had been drained, were found in the midst of bronchopneumonic areas. Multiple abscesses of the brain also were present.

Group IV. Perforated Solitary Pulmonary Abscess.—A variety of lesions fall into this group, but do not lend themselves to subgrouping. Two examples are chosen, not so much to illustrate the pathologic features as to point to the results of logically conceived treatment in one case and incorrect treatment in the other.

CASE 11.—G. G., male, 40 years old, was ill for two weeks when admitted to the Hospital for Joint Diseases. At the onset there were severe pain in the right chest, fever, and cough. Purulent expectoration began soon thereafter and became profuse. An early film disclosed a circular shadow in the right lower lobe, which was obscured in a later film by the homogenous shadow of a pleural effusion. Aspiration of the chest revealed pus. At operation a large empyema, situated posterolaterally, was entered and evacuated. The perforation of a pulmonary abscess was visualized. It was enlarged, and an abscess cavity of substantial proportions was unroofed. Expectoration of pus ceased promptly after operation and did not recur. Subsequently an anterior, parapericardial empyema, derived from an interstitial perforated pulmonary abscess, was drained. These two empyemas were separate and distinct from each other. Finally an encapsulated pleural infection in the right axillary region was opened and was found to be derived from an adjacent small perforated interstitial abscess. It was unrelated to either of the two previously mentioned perforated abscesses. Complete recovery followed the third operation. Of the three perforated abscesses in this case, only the first, characterized by the expectoration of pus, was of the segmental type which is the subject of this paper.

CASE 12.—E. N., female (Hospital No. 375,996), 30 years old, was operated upon in March, 1933, for a pneumococcus pyopneumothorax. At first, closed drainage was performed. After the acute phase had subsided, an open thoracotomy for the residual empyema was performed. Cough, purulent expectoration, and fever persisted for several weeks after operation, and then all manifestations gradually subsided. The wound healed slowly, a bronchial fistula being present for two months.

The patient appeared to be entirely well in July, 1933, at which time she was operated upon for cholecystitis and cholelithiasis. There were no symptoms referable to the chest during her convalescence.

In October, 1933, occasional cough, purulent expectoration, and small hemoptyses began. The patient entered the hospital one year later (November, 1934), shortly after a large hemoptysis. A bronchogram revealed a cavity in the right upper lobe. Operation was performed, and a chronic abscess of the lung unroofed. A bronchial fistula, perforation into the pleura, and chronic encapsulated empyema were found. The pulmonary abscess was the original one, which had not been sought and cared for at the operations performed for the pleural infection in 1933. The operative procedure was difficult and a revision, for better drainage of the pulmonary cavity, was required in 1935. The patient has been well since that time, and a bronchogram demonstrates a normal bronchial tree.

Although not noted in all cases, there are three distinctive features of pulmonary abscess in children: (1) unusually early and extensive destruction and excavation of the lung, (2) early invasion of the pleura, (3) absence of expectoration of pus, even in older children. Examples of perforated solitary pulmonary abscess will be given to illustrate (1) the problem of management of a perforated pulmonary lesion with limited empyema, (2) the correct and incorrect treatment of perforated pulmonary abscess with total or subtotal pyopneumothorax.

CASE 13.—I. H., male (Hospital No. 364,367), 11 months old, was admitted in April, 1934, with a history of pneumonia of the right upper lobe of one week's duration. He was under hospital observation for eleven days, during which time there were fever, cough, and roentgen evidence of a progressively destructive lesion of the right upper lobe. By the time the patient came to operation, a very extensive lesion involving most of the upper lobe, with multiple fluid levels, was seen in the x-ray film. The operative procedure consisted of the drainage of an encapsulated pyopneumothorax and the enlargement of the pulmonary opening. The enormous multilocular pulmonary cavity, with its numerous bronchial fistulas, was converted essentially into a single cavity by the division of septa, and was packed.

There was prompt subsidence of clinical evidence of suppuration, and the cavity was clean two weeks after operation. At that time, autotransplantation of fat into the cavity was performed in the hope that the difficult problem of lattice lung would be obviated. The wound healed over the graft, the child has remained symptom free, and x-ray check-ups of the chest in the past four years have disclosed no abnormalities.

CASE 14.—R. B., female (Hospital No. 415,912), 11 months old, was admitted in October, 1937, and was under observation for two weeks with the diagnosis of pneumonia followed by empyema. Aspiration of the chest revealed pus. The only reason for suspecting the existence of a pulmonary abscess was the presence of areas of rarefaction within the shadow of pneumonic infiltration. As proved by operation, the abscess would have been overlooked if, on the basis of the roentgen findings, it had not been especially sought. The bilocular empyema, situated in the axilla, was first laid open. Its anterior limits were then explored because the suspected pulmonary abscess was localized in the anterior axilla. A narrow purulent tract was followed and found to enter an empyema which led to the site of perforation of a pulmonary abscess of substantial proportions. After the removal of a

section of an additional rib, the pulmonary abscess as well as the empyema could be adequately unroofed. Both cavities were then packed. Convalescence was uneventful, and there was early obliteration and healing of both cavities. The perforated pulmonary abscess was undoubtedly the source of the empyema in this case. However, the communication between them consisted of a narrow tract which had to be sought. Its discovery and the resultant surgical management of the pulmonary abscess comprised a simple solution of a problem which might have proven difficult if deferred to a subacute or chronic phase. Furthermore, the complications of a persistent, untreated pulmonary abscess were eliminated by early adequate drainage.

CASE 15.—R. M., male (Hospital No. 386,733), 19 months old, was admitted in November, 1935. The first operation consisted of closed drainage of a large, tense



Fig. 8.—I. H. Extensive pyopneumothorax encapsulated over upper lobe. Note multiple fluid levels lying partially within the lung and partially within pleura.

pyopneumothorax at a time when the patient was in a critical condition. There was prompt improvement. Enormous quantities of air escaped for days through the underwater system, thus offering evidence of a perforated pulmonary abscess of substantial proportions. With the subsidence of the hyperacute clinical manifestations, consideration was given to the fact that a large perforated pulmonary lesion existed and was associated with a total or subtotal pneumothorax. Accordingly, a definitive operation was decided upon five weeks after the primary one, with the object of closing the large pulmonary defect. The lesion, exposed by the excision of sections of two ribs, consisted of a typical lattice lung, presenting a number of major bronchial fistulas. The lung adjacent to the blown out abscess was adherent. It was freed in part, and was sutured over a fat graft. There was some leakage of

air from the operative site, with resultant postoperative pneumothorax. The latter cleared up slowly. The lung has remained expanded and free from pulmonary infiltration.

CASE 16.—R. B., male (Hospital No. 399,494), first came under observation in 1932 at the age of 5 years, and the nature of the problem best will be appreciated when attention is called to the fact that the child was not well until the end of 1937, after a long series of hospital admissions and operations. When admitted in 1932, there was a history of pneumonia in 1930 followed by empyema and coinci-



FIG. 9.—I. H. Lateral view. The multiple pyopneumothoraces are confined to the anterior and axillary portion of the thorax. The necessity of lateral films for localization even of large encapsulated lesions is evident.

dental expectoration of purulent material. The pleural infection was treated by repeated aspiration and injection of air. This resulted in complete collapse of the lung and persistent pneumothorax. Since that time there were recurrent attacks of fever and cough. Shortly after admission to Mount Sinai Hospital, exploratory thoracotomy was performed. The lung was found collapsed and fixed against the mediastinum; there was a large pulmonary excavation in the lower lobe with the characteristic features of lattice lung, and purulent exudate was present over the adjacent pleura. Sections of several ribs were excised for purposes of direct drainage of the pulmonary lesion. A number of thoracoplastic operations were performed upon subse-

quent admissions, in order to obliterate the large pleural dead space. They succeeded only partially, and the lattice lung persisted. Finally, in order to eradicate the lesion, removal of the lower lobe was performed. A bronchial fistula persisted, which was closed by means of a fat graft. The patient has remained well since that time.

Group V. Perforated Multiple Pulmonary Abscesses.—As already indicated, these cases, occurring most often in children, are apt to be fulminating and fatal in their course, and usually do not present



Fig. 10.—F. Widely separated perforated pulmonary lesions with multiple encapsulated pyopneumothoraces. The latter are more evident in the lateral than in the posteroanterior film.

problems for surgical management other than emergency measures for temporary palliation. The following are unusual instances in which operative treatment was indicated.

CASE 17.—L. B., female (Hospital No. 410,035), 23 years old, was admitted in April, 1936. The illness began six weeks before, with fever, chill, and chest pain, and the expectoration of bloody sputum. Subsequently the sputum became purulent. The diagnosis of bronchopneumonia followed by "pleurisy" was made. She was in the hospital for ten days with high fever, dyspnea, cyanosis, and rather purulent expectoration. Only after several exploratory aspirations was purulent fluid encountered in the pleura. At operation, a most extensive multilocular empyema was revealed. Separate collections of pus reached from the posterior aspect of the

apical portion of the lung down to the diaphragm. In addition, there was an intrapulmonary empyema which could be evacuated only after detachment of the adherent lower lobe from the diaphragm. There were several underlying perforated pulmonary abscesses, which were split open by crucial incisions. Pulmonary and pleural abscess cavities were packed. Fever and some purulent expectoration continued for six weeks after operation, apparently due to areas of necrosuppurative bronchopneumonia. The extensive wound progressed satisfactorily. A sinus persisted for many months, but finally healed. The patient has been entirely well and symptom-free. The bronchogram was normal except for the crowding together of several of the bronchi of the lower lobe.

CASE 18.—M. H., female (Hospital No. 348,206), 38 years old, was admitted in January, 1933, with a four weeks' history of bilateral bronchopneumonia. The lesions appeared almost simultaneously in both lungs and were characterized by chest pain, fever, cough, and purulent expectoration. The latter was progressive, but fever tended to subside. Shortly before admission, collapse phenomena supervened. An x-ray film, taken directly after admission, revealed multiple bilateral pulmonary abscesses with perforation of one of them and consequent pyopneumothorax in the right axilla, and an empyema on the left side. The first operation was performed on the right side. A bilocular pyopneumothorax, derived from a perforated lung abscess, was unroofed. One week later, the left-sided bilocular empyema was drained. This, too, was found to be derived from a perforated pulmonary abscess. The postoperative course was satisfactory and was characterized by spontaneous healing of all of the unperforated pulmonary cavities. The patient has remained well, and a recent roentgenogram (1938) is essentially negative.

SUMMARY AND CONCLUSIONS

Segmental aerobic abscess of the lung is a complication of necrosuppurative bronchopneumonia. The latter term was coined because the coexistence of suppuration and necrosis characterizes the disease. The pathology, and the clinical and roentgenographic features of necrosuppurative bronchopneumonia are described.

Acute aerobic abscess of the lung is no longer a rare lesion because the incidence of necrosuppurative bronchopneumonia has greatly increased. The stage of transition between necrosuppurative bronchopneumonia and aerobic pulmonary abscess is not recognizable clinically.

Aerobic pulmonary abscess is seen in two important forms: interstitial and segmental. The latter alone is the subject of the present communication. Of the two forms in which it occurs (the multiple and the solitary), the solitary abscess is usually the only variety which is of surgical significance.

Three classes of solitary abscess are described: (1) pulmonary abscess as an incidental part of an extensive necrosuppurative bronchopneumonia; (2) pulmonary abscess as the predominating lesion within an extensive area of necrosuppurative bronchopneumonia; (3) typical pulmonary abscess surrounded by a more or less sharply limited and narrow zone of infiltrated lung.

There are pathologic features which are common to all three varieties: substantial size, monolocularity, superficial situation within a pulmo-

nary lobe, overlying agglutinating pleural adhesions, more or less extensive destruction of bronchi.

The clinical manifestations of segmental pulmonary abscess are essentially indistinguishable from those of the antecedent necrosuppurative bronchopneumonia. The differentiation must be based on roentgenographic findings. Pulmonary abscess must be differentiated from other pulmonary diseases, also, especially tuberculosis and neoplasm.

The indications for operative treatment, which have as yet not been completely formulated, are discussed in detail. Correct operative approach is based upon accurate preoperative localization of the lesion. The operative method which is advocated is a single stage procedure. Details of the operation for perforated and unperforated lesions are given. Postoperative treatment is described.

The results of operation in the three varieties of aerobic abscess, as well as in perforated abscess, are indicated in the case reports. Operation for pulmonary abscess in Classes 1 and 2 has been unsatisfactory. Operation for abscess in Class 3 has been followed by cure in every instance.

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INCIDENCE OF AIR-BORNE BACTERIA IN THE MAJOR SURGERY OF THE MULTNOMAH COUNTY HOSPITAL

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THE PRESENCE of air-borne bacteria is at present considered inescapable in any peopled room. Nevertheless, a surgery cannot be viewed as any ordinary room. The incidence of bacteria in the air of such a room is a matter of professional concern to the surgeons and of vital concern to the patient. Surgeons during the Listerian era of antiseptic surgery took elaborate precautions to minimize this source of sepsis. Although no phenol sprays are in use today, just as elaborate precautions are observed in decreasing the sepsis from other sources, the surgeons rightly considering air-borne contamination of relatively minor moment. Aseptic surgery has derived its lease on efficacy through rigid adherence to bacteriologic principles. With the almost ritualistic refinements in surgical technique eliminating previous major sources of sepsis, the question of air-borne contaminants is promoted to a status of major importance. The contemporary surgical literature gives token of awakened interest in this subject.¹⁻¹⁴ For this reason an investigation of the incidence of air-borne bacteria in the major surgery of the Multnomah County Hospital was considered to be of interest.

EXPERIMENTAL PROCEDURES

Fresh human oxalated blood was used in the preparation of blood agar plates. With each set of ten plates so prepared, two control plates were made and incubated concurrently. The plates were then retained in the refrigerator of the Multnomah County Hospital surgery until an opportunity for exposure presented itself. The plates were placed in designated spots and marked according to their disposition, in accordance with a map of the major surgery (Fig. 1). Exposure was for a constant period of 30 minutes. At the expiration of this interval, the plates were covered, collected, and incubated at 37° C. A count of the colonies was made at 24, 48, 72, and 96 hours. After three sets of plates had been so incubated, however, it was found that incubation longer than 48 hours resulted in a spreading overgrowth of the colonies in a fashion making an accurate count impossible. As a result of this, only the figures obtained at 48 hours were considered significant. At no time during the period of incubation were the covers of the Petri plates lifted. When the designated period of incubation had been passed, the

covers of the plates were lifted and identification of the colonies attempted. Exact determination of the separate colonies was considered beyond the scope of this paper. From a naked-eye examination of the colonies, a fairly accurate identification of the streptococcus and staphylococcus colonies could be made. A sufficient number of small hemolytic staphylococcus colonies were checked microscopically to insure reasonably accurate differentiation from the streptococcus colonies. No attempt was made beyond this. If a colony did not present the characteristics of the organisms named, it was classed with the unidentified group. This latter would include, undoubtedly, such organisms as *Proteus vulgaris*, *Escherichia coli*, *Neisseria catarrhalis*, *Bacillus subtilis*, and other common bacteria.

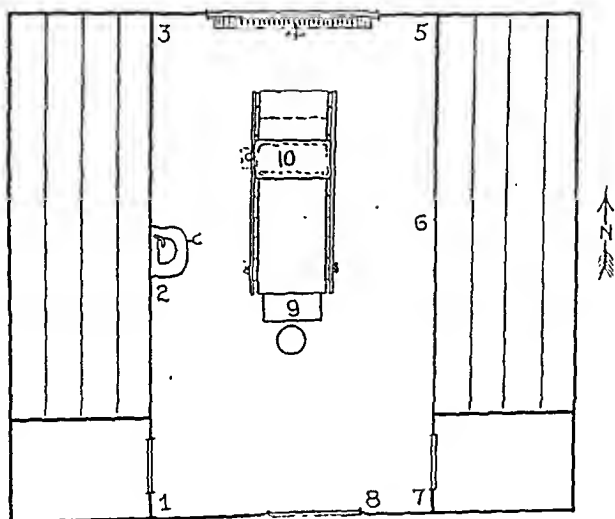


Fig. 1.

RESULTS

The results obtained from this investigation are summarized in the accompanying tables and charts. The contributing factors to an increase in the number of air-borne contaminants is well illustrated in Table I and shown graphically in Fig. 2. Under basal conditions at night with the surgery unentered, there is a relatively low incidence of bacteria. In the day, even though the surgery was unentered during the actual exposure time, the air had been sufficiently agitated to produce a slight rise in the count. When the plates were exposed with the doors left open and people entering, there was a significant rise in the bacterial count. The source of this increase may be explained by: (a) exogenous bacteria brought in from outside the surgery in the wake of the entrants, (b) endogenous bacteria wafted from their previous resting places in the

breeze created by the movements of those entering, or (c) contaminants from the nasopharynx of the unmasked entrants. This count is by no means as significant as the counts found on plates exposed during operative procedures. A sharp rise in the number of bacteria is noted immediately upon putting the surgery to its proper use. This mounts steeply when one section of ten students is placed in the balconies. Fig. 3

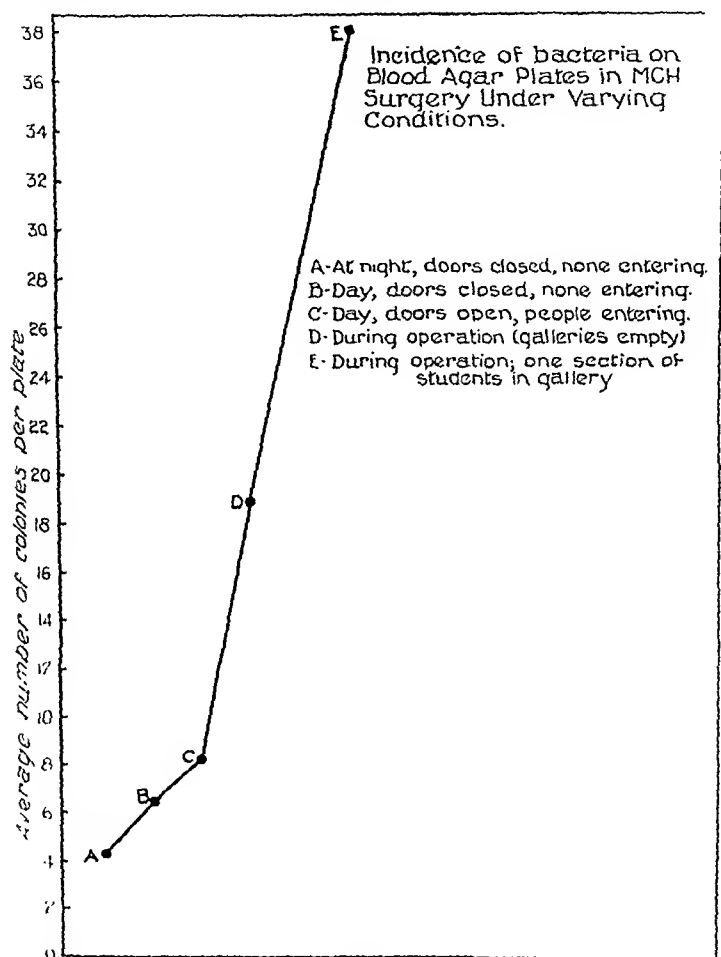


FIG. 2.

shows graphically the increase in the type of organism. It is to be noted that no hemolytic streptococci are found until operative procedures are undertaken. At this time both the streptococci and the *Staphylococcus albus* show a marked increase. Table III shows the estimation of the number of bacteria falling on a sterile operating field in one hour as estimated by various workers. Meleney² estimated that a Petri plate covered 7 square inches and that the usual operating field covered an area of

TABLE I

NUMBER OF BACTERIAL COLONIES ON BLOOD AGAR PLATES INCUBATED AT 37° C. FOR 48 HOURS AFTER A 30-MINUTE EXPOSURE IN LOCATIONS DESIGNATED BY NUMBER IN FIG. 1

| PLATE NUMBER | CONDITIONS OF EXPOSURE* | | | | |
|-----------------|-------------------------|----|----|----|-----|
| | A | B | C | D | E |
| 1 | 7 | 6 | 10 | 26 | 164 |
| 2 | 3 | 9 | 12 | 23 | 58 |
| 3 | 4 | 4 | 6 | 25 | 43 |
| 4 | 3 | 6 | 7 | 26 | 47 |
| 5 | 5 | 4 | 30 | 27 | 49 |
| 6 | 1 | 5 | 3 | 11 | 38 |
| 7 | 5 | 8 | 8 | 13 | 32 |
| 8 | 6 | 11 | 12 | 21 | 30 |
| 9 | 5 | 5 | 8 | 12 | 52 |
| 10 | 4 | 8 | 12 | | |

*A—At night with doors closed and no one entering surgery. B—During day with doors closed and no one entering surgery. C—During day with doors open and people entering surgery. D—During course of day's operations with balconies empty. E—During operation with one section of students in balconies.

from 4,000 to 7,000 square inches. This included the area occupied by the sterile instrument tray, the actual operating field, and the rinse basins. It is from these figures that all estimations are made.

TABLE II

AVERAGE BACTERIAL COLONY PER PLATE UNDER CONDITIONS OF EXPOSURE AND INCUBATION DESCRIBED IN TABLE I

| BACTERIAL TYPE | AVERAGE NUMBER OF COLONIES PER PLATE* | | | | |
|------------------------------|---------------------------------------|-----|-----|------|------|
| | A | B | C | D | E |
| Hemolytic streptococcus | 0.0 | 0.0 | 0.0 | 4.2 | 5.0 |
| Nonhemolytic streptococcus | 0.0 | 0.5 | 0.8 | 5.2 | 5.5 |
| <i>Staphylococcus albus</i> | 2.2 | 3.4 | 3.7 | 9.2 | 16.0 |
| <i>Staphylococcus aureus</i> | 1.1 | 0.1 | 1.1 | 1.7 | 3.5 |
| Fungi | 0.1 | 0.7 | 0.0 | 0.25 | 0.6 |
| Not identified | 0.1 | 0.7 | 0.3 | 9.7 | 18.3 |
| Overgrown plates | 0.0 | 0.0 | 2.0 | 5.0 | 3.0 |
| Total colonies (all) | 4.3 | 6.6 | 8.3 | 19.0 | 37.3 |

*The identification under conditions B, C, and D was made after the plates had been incubated for 96 hours.

COMMENTS

As previously stated in this work and as emphasized by Gardner,¹ Meleney,² and Hart,⁴ when the improvement in surgical technique reduces other sources of sepsis to a minimum, then by comparison air-borne

TABLE III

NUMBER OF BACTERIA FALLING ON STERILE OPERATING FIELD IN ONE HOUR AS ESTIMATED BY VARIOUS WORKERS

| AUTHORITY | NUMBER OF BACTERIA | COMMENT |
|--------------|--------------------|-----------------------------------|
| Meleney | 35,000-60,000 | |
| Davis | 19,000-35,000 | |
| Hunt | 44,000-78,000 | "Old-fashioned" surgery |
| Our estimate | 21,000-38,000 | Usual operation galleries empty |
| Our estimate | 42,000-74,000 | One section students in galleries |

contamination becomes a question of major concern to the surgeon. From this study it does not appear that air-borne contamination is at an irreducible minimum in the major surgery of the Multnomah County Hospital. No attempts are made herewith to proffer suggestions, its being held that this is rightly the province of the surgeons concerned. It is, nevertheless, an interesting topic for speculation. It is noted that when activity commences in the surgery and the doors are permitted to remain open, the bacterial count rises. The assumption that this increase is due

Average Bacterial Colony Count in MCH Surgery
Blood Agar Plates Exposed Under Varying Conditions

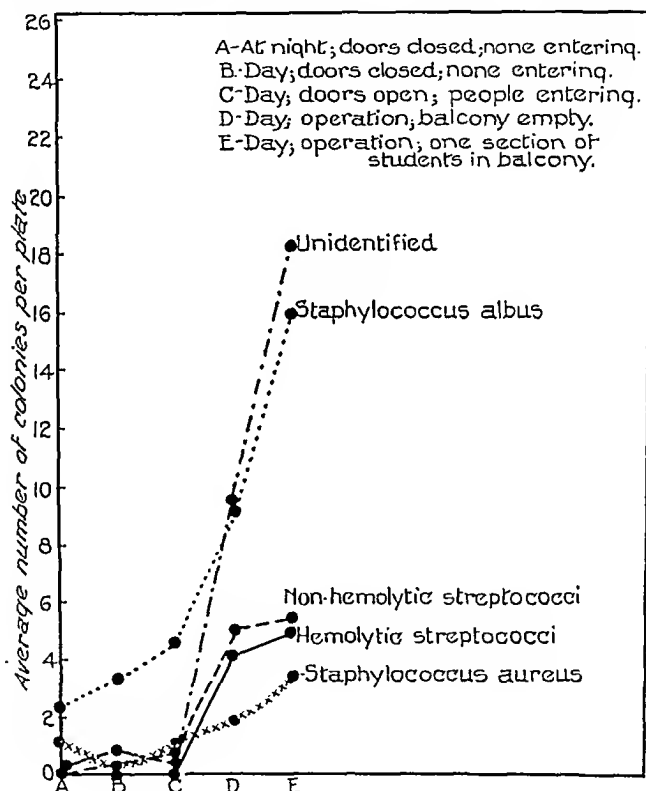


Fig. 3.

in part to the agitation of air currents by passage of the operating room assistants does not appear to be unwarranted. It is possible that some bacteria are carried into the surgery by the footgear. Meleney has suggested that a pair of shoes to be worn exclusively in the surgery be provided by the surgeon and his assistants.

Much variation in masking is noted among the surgeons operating at the Multnomah County Hospital. Some mask only the mouth, allowing the nose to project over the mask. Others include both the nose and the

mouth. Some of those who approach closely to the operating table in the role of spectators (internes and residents) are entirely unmasked and ungowned. There is, it seems, in some instances, a possibility of inadequacy of masking. The sharp increase in bacterial count occurring as soon as students are placed in the balconies is of interest. None of the students are gowned or masked and many of them are found in the balconies in street clothing, surely a possible source of added contamination.

Since the hemolytic streptococci and *Staphylococcus albus* show the greatest proportionate increase after activity commences in the surgery, it appears very probable that the major source of contamination is the nasopharynx. These two organisms are well known inhabitants of the nasopharynx and seem to dominate the bacterial picture as soon as people enter the surgery.

Many methods for reducing the number of bacteria in operating rooms have been suggested, among them being: (1) meticulous gowning and masking of all who enter the surgery and exclusion of all who manifest an upper respiratory infection (Meleney), (2) adequate masking with specially constructed masks (Waters), (3) separating the balconies from the surgery by plate glass partitions (Meleney), (4) irradiation of the air immediately surrounding the operative field (Hart), (5) sterilization of the air in the surgery by filtering through bactericidal solutions (Walburn and Reymann), and (6) providing covers for all exposed sterile surfaces (Foster).

SUMMARY

1. The number of air-borne bacteria in the major surgery of Multnomah County Hospital is roughly proportional to the number of people present in the surgery and to the activity on the floor proper of the surgery.

2. The greatest proportionate rise in incidence is manifested by the streptococci and the *Staphylococcus albus*.

3. The organisms showing this rise are acknowledged to be common inhabitants of the nasopharynx.

4. The estimated number of bacteria falling per hour on a sterile operating field compares unfavorably with similar figures obtained in other hospitals.

The authors wish to thank Dr. H. J. Sears, head of the bacteriology department of the University of Oregon Medical School, for his interest and suggestions.

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OSTEOPSATHYROSIS

WITH A REPORT OF THREE CASES*

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IN 1833 Lobstein described a type of bone fragility he had observed among a group of people who suffered multiple fractures and dislocations as a result of slight trauma. He designated this disease "osteopsathyrosis." Since that time many others have described the same bone pathology under the following titles: osteomalacia congenita, rachitis foetalis annularis, malacia myeloplastica, periosteal dysplasia, dystrophia periosteal, osteitis parenchymatosa chronica, micromelia annularis, osteoporosis congenita, fragilitas ossium, and osteogenesis imperfecta.

Although Lobstein drew attention to the abnormal skeletal portion of the body, later writers have pointed with greater force to the blue sclera and other variable characteristics associated with osteopsathyrosis. These variable factors have been studied in their incidence to determine their value in the diagnosis of the disease.

Osteopsathyrosis is described as occurring in three age groups. (1) The *congenital* group are born dead or die soon after birth and are found to have received numerous fractures during delivery. (2) The *infantile* group are apparently normal at birth, but in their first few years experience repeated fractures and dislocations. Wrölick, in 1849, designated this form as fetal rickets. (3) The *juvenile* group do not show the skeletal abnormality until late childhood or about the age of puberty. It is notable that this condition, like many other diseases, shows periods of remission and activity.

The case histories of three patients diagnosed as having osteopsathyrosis are presented. It is to be emphasized that these patients are related, as the family tree indicates.

CASE REPORTS

CASE 1.—G. T., a white female, aged 6 years, was admitted to the Memorial Hospital on Jan. 17, 1930. The mother stated that when the child was three weeks old she received a fracture of the left humerus when lifted from her bed. At seven weeks, as she was being turned, she received a fracture of the left femur. Later, a clavicle and both humeri were fractured on separate occasions. By the time she was 6 years old, ten additional fractures had occurred. With the exception of one fracture of the left tibia, these later fractures were equally distributed between the two femurs. After each fracture, rapid union of the fragments took place with the formation of abundant callus.

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Physical Examination.—At the age of 6 years this girl was 40 inches tall. The skin, hair, and nails were normal. The head was normal in size, shape, and proportion. The eyes were equal in size and shape, and there was a slight azure hue to the sclera. The ears, nose, and mouth were essentially normal. The tongue, mucous membranes, and gums were normal; some dental caries was present. There was no lymphadenopathy. The chest and abdomen were essentially normal. The genitals were normal. Grossly, the extremities were normal except for some slight deformity at the sites of repeated fractures.

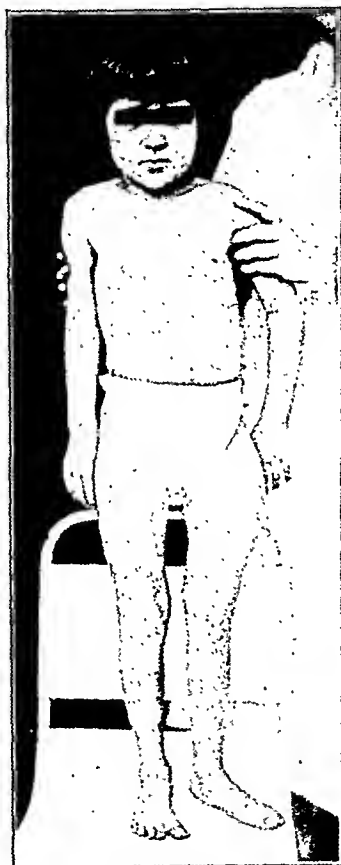


Fig. 1.—Photograph of patient (Case 1) at age of 6 years. Note beginning distortion of the left thigh from repeated fractures.

Laboratory Data.—Urine normal. Test for Bence-Jones protein, negative. R.B.C., 5,400,000; W.B.C., 9,000; hemoglobin, 92 per cent. Stool examinations negative for ova, parasites, and fatty bodies. Basal metabolic rate plus 8. Wassermann negative.

| BLOOD ANALYSIS | | SPINAL FLUID ANALYSIS (MADE SIMULTANEOUSLY WITH BLOOD) |
|----------------|------|---|
| Calcium | 11.5 | 5.2 |
| Phosphorus | 4.5 | 1.9 |
| Total protein | 7.7 | |
| Serum albumin | 5.9 | |
| Globulin | 1.8 | |

X-ray Examination.—A summary of the x-ray findings in Case 1, extending over a period from the age of 5 weeks to 6 years, is as follows:

There is no miliary granular appearance of the skull vault or flat bones as is characteristic of hyperparathyroidism. There is a generalized "ground glass" density of most of the long bones with slight thinning of the cortices and an irregular trabeculation at their distal ends. The epiphyses at the knees are normal in appearance. The epiphyseal centers of the patellas are just beginning to show.

Old healed fractures of the femurs are present and more recent fractures surrounded by abundant callus are also seen. There is slight anterior and lateral bowing of the left femur.

A flat plate of the genitourinary tract does not reveal evidence of calcium deposits in the region of either kidney. A barium enema demonstrated a normal colon with a competent ileocecal valve.

This series of x-ray studies does not show the effects of scurvy, rickets, or syphilis.

CASE 2.—A. T., a white female, aged 19 years, was admitted to the Memorial Hospital on July 4, 1929. She was brought to the hospital unconscious, having a subtrochanteric fracture of the right femur which resulted from an automobile accident. Her recovery from this accident was uneventful. In her past history there had been repeated fractures involving nearly all the bones of the body. X-rays revealed many healed fractures, most of which were in malposition.

Physical Examination.—The woman was obese, dwarfed, and appeared to be much older than 19 years. Her head was normal in size and appearance. The eyes, ears, nose, and mouth were not remarkable. The heart and lungs were normal. The abdomen was pendulous, but no other abnormality was noted. There was marked bowing of both thighs, especially at the hips, but no measurable inequality in length. There was an unusual body contour found to be the result of the distortion of proportions accompanying a marked scoliosis and lordosis of the spine. The thorax was elongated and narrowed and the pelvis was shallow and flattened.

Laboratory Data.—Urine normal. Test for Bence-Jones protein, negative. R.B.C., 4,500,000; W.B.C., 8,000; Wassermann negative.

X-ray Examination.—X-ray plate of the skull shows both the inner and outer tables as well as the diploe of both parietal bones to be thin. This is most prominent near the longitudinal suture.

A plate of the pelvis and upper femurs shows a flattened and deformed pelvic girdle with coxa vara of both femurs. There is a recent fracture through the neck of the right femur and several healed fractures involving the upper portion of both femurs. The cortex of the femur is thin and the medullary cavity wide. The bones all demonstrate an abnormal "ground glass" density.

Note.—This patient was seen again at the age of 22 years, after a fall. X-rays at this time showed the fracture of three years before to be well healed and there were no later fractures.

CASE 3.—W. T., a white male, aged 42 years, was admitted to the Memorial Hospital on June 23, 1935. He had received a fracture of the shaft of the right femur when he "turned about on his heel." Inquiry into his past history revealed that this was the fourteenth fracture of the femur he had had, these injuries being distributed equally between the two sides. The first fracture of the femur occurred at the age of 4 years. There had been a lapse of twelve years between the thirteenth and fourteenth fractures, during which time he had led a normal active life as a telegraph operator. During his boyhood, he had received a fracture of the clavicle while playing football.

He was treated by appropriate fixation of the leg in a plaster cast but failed to develop callus at the site of the fracture. A sliding bone graft was placed over the fracture in the hope of promoting healing but this succeeded in bringing about only a fibrous union.

Physical Examination.—The man was poorly developed and dwarfed in appearance. The skin, hair, and nails were normal. The head was unusual in that the frontal bones were high and the mandible and maxilla were very prominent. The calvarium had the contour of an army fatigue hat, suggesting late closure of the



Fig. 2.—Photograph of patient (Case 3) at age of 45 years. Note advanced distortion of the body resulting from repeated fractures.

fontanelles or thinning along the suture lines. The eyes, ears, and nose were essentially normal. All teeth were absent and the gums were atrophic. There was a marked lordosis of the vertebral column and the thorax was short and distorted in compensation to the spinal contour. The chest and abdominal organs were apparently normal. The genitals were normal. Grossly, the upper extremities were normal; whereas, beginning with a flattened pelvis, the lower extremities were markedly bowed and distorted.

Laboratory Data.—Urine normal. Test for Bence-Jones protein, negative. R.B.C., 4,200,000; W.B.C., 9,000. Wassermann negative. Basal metabolic rate plus 7.

X-ray Examination.—On x-ray examination there is a destructive change involving the inner and outer tables and diploe of both parietal bones near the longitudinal suture. There is marked scoliosis and lordosis of the spine with corresponding deformity of the chest. There is marked deformity of the pelvis and coxa vara of both femurs with marked inward bowing of both tibia and fibula. At the ends of most of the long bones there is an increased trabeculation associated with a thin cortex and a wide medullary cavity. All the bones of the body show an unusual "ground glass" density. However, there are no definite miliary granular changes in the skull vault as seen in cases of hyperparathyroidism.



Fig. 3.—Photomicrograph of section of bone removed from the femur (Case 3). This demonstrates the unusual architecture of the bone and the relationship between the fibroblastic stroma and solid bone which form the cortex of the femur. The photomicrograph shows the sites selected for high power photomicrographs shown in Figs. 4 and 5.

An x-ray of the genitourinary tract does not demonstrate any density in the region of the renal pelves.

BIOCHEMISTRY

Biochemical studies involving a large number of determinations on Cases 1 and 3 revealed no remarkable departure from the normal. The average blood chemistry values are given in Table I.

fig. 4.

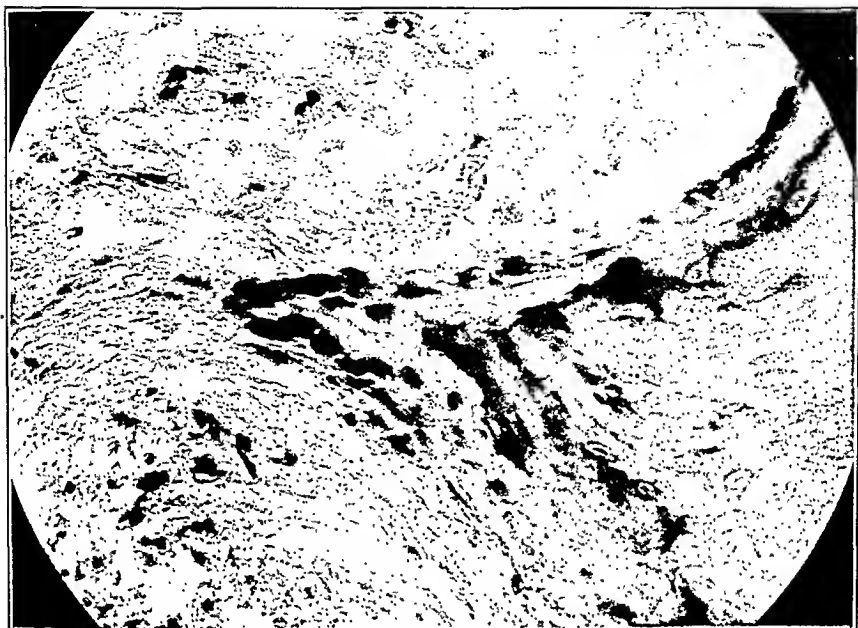


fig. 5.



Fig. 4.—High power photomicrograph of section of bone from the femur, showing active osteoblasts at the point of contact between the fibroblastic stroma and the solid bone.

Fig. 5.—High power photomicrograph of solid portion of the cortex, showing the abnormal lamellar structure.

TABLE I
BLOOD CHEMISTRY STUDIES

| | N.P.N. | SUGAR | CALCIUM | PHOSPHORUS | PHOSPHOTAS. |
|--------|--------|-------|---------|------------|-------------|
| Case 1 | 24 | .85 | 11.08 | 4.5 | 6.8 |
| Case 3 | 31 | .95 | 10.5 | 4.5 | 6.3 |

*Bodansky method with a value of 5.4 in the blood of a normal individual.

Calcium and phosphorus retention studies while the patients were on a normal diet were not significant. Only the average values for the whole period in each case are to be considered, since there must always

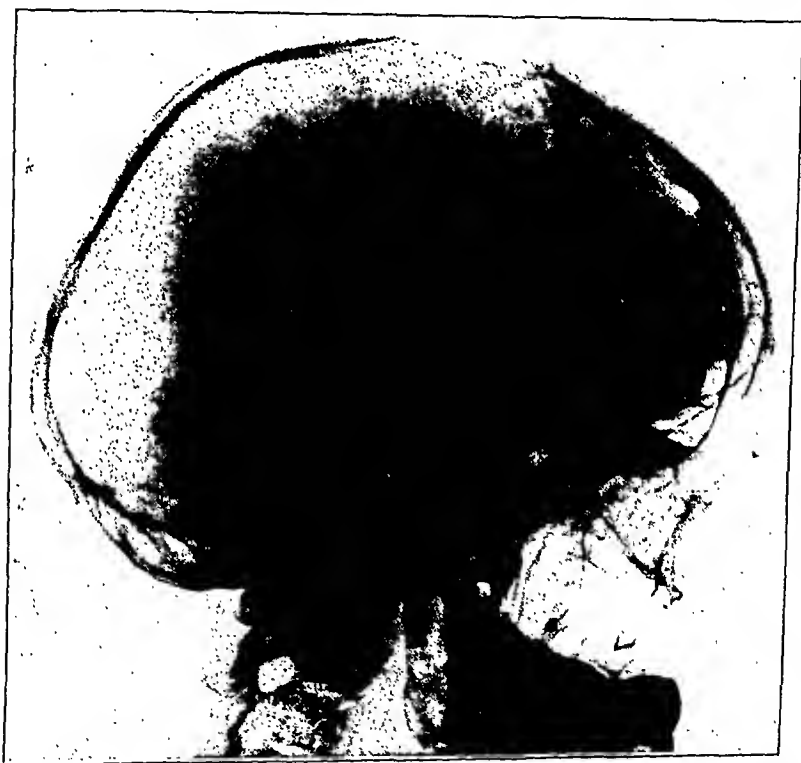


Fig. 6.—Lateral view of the head of Case 3, showing thin diploe of the skull and failure of closure of anterior fontanel.

be a carry-over from one short period to the next. As the length of periods of observation is increased, greater accuracy of the results is obtainable.

It was demonstrated that there is no difficulty in absorption of calcium and phosphorus from the enteric tract since more than 50 per cent of the phosphorus excretion appeared in the urine. In comparing the values submitted in the Tables II and III, one must resort to tables of the normal for the age of the patient and not check them against each other.

TABLE II*
CALCIUM AND PHOSPHORUS RETENTION STUDIES, WHILE PATIENT RECEIVED NORMAL DIET

| CALCIUM AND PHOSPHORUS IN URINE, WHILE PATIENT RECEIVED NORMAL DIET | | | | | | | | | | | | | | |
|---|------------|-----------------------|-------|----------------|------------------------|-------|----------------|-----------------------|-------|----------------|----------|-------------------------|------|-----|
| | | FIRST PERIOD (2 DAYS) | | | SECOND PERIOD (2 DAYS) | | | THIRD PERIOD (2 DAYS) | | | | DAILY AVERAGE RETENTION | | |
| | | FOOD | URINE | FECES RETAINED | FOOD | URINE | FECES RETAINED | FOOD | URINE | FECES RETAINED | RETAINED | | | |
| A. Case 1 | Calcium | 1762 | 147 | 1130 | 485 | 2172 | 150 | 1750 | 272 | 2259 | 223 | 978 | 1058 | 302 |
| | Phosphorus | 2017 | 1277 | 671 | 69 | 2706 | 1330 | 863 | 513 | 2832 | 1221 | 514 | 1097 | 279 |
| B. Case 3 | Calcium | 1605 | 456 | 1291 | -142 | 2142 | 340 | 893 | 909 | 1943 | 328 | 930 | 685 | 242 |
| | Phosphorus | 2155 | 1365 | 775 | 15 | 2060 | 936 | 636 | 488 | 2112 | 915 | 608 | 589 | 182 |

TABLE III*
CALCIUM AND PHOSPHORUS RETENTION WITH CALCIUM PHOSPHATE AND COD LIVER OIL FORTIFIED WITH VITAMIN D COMPLEMENT

| TABLE III* RETENTION WITH CALCIUM PHOSPHATE AND COD LIVER OIL FORTIFIED WITH VITAMIN D COMPLEMENT | | | | | | | | | | | | |
|--|-----------------------|-------------|-------------------|------------------------|--------------|-------------------|-----------------------|------------|-------------------|-------------------------------|-------------------|-------------|
| Case 1 Calcium Phosphorus | FIRST PERIOD (3 DAYS) | | | SECOND PERIOD (3 DAYS) | | | THIRD PERIOD (3 DAYS) | | | DAILY AVERAGE RETENTION | | |
| | FOOD | URINE | FECES RETAINED | FOOD | URINE | FECES RETAINED | FOOD | URINE | FECES RETAINED | FOOD | FECES RETAINED | |
| | 7299 6403 | 358 2224 | 6613 4040 | 328 139 | 6248 5512 | 309 1243 | 6002 3475 | -37 794 | 6443 5130 | 416 1952 | 4768 2622 | 1259 556 |
| *All values are reported in milligrams. The calcium and phosphorus content of the diet was determined by analysis of identical trays. The author wishes to acknowledge the cooperation of Miss Kathryn Heftshu, of the Dietetic Department, in the preparation of these tables. | | | | | | | | | | | | |

*All values are reported in milligrams.

The calcium and phosphorus content of the diet was determined by analysis of identical trays. The author wishes to acknowledge the cooperation of Miss Kathryn Heftshu, of the Dietetic Department, and Dr. J. C. Forbes, of the Bio-chemical Department, in the preparation of these tables.

It is to be noted that, when Case 1 was fed a diet to which calcium phosphate and cod liver oil fortified with vitamin D complement were added, the calcium and phosphorus retention was not increased, but

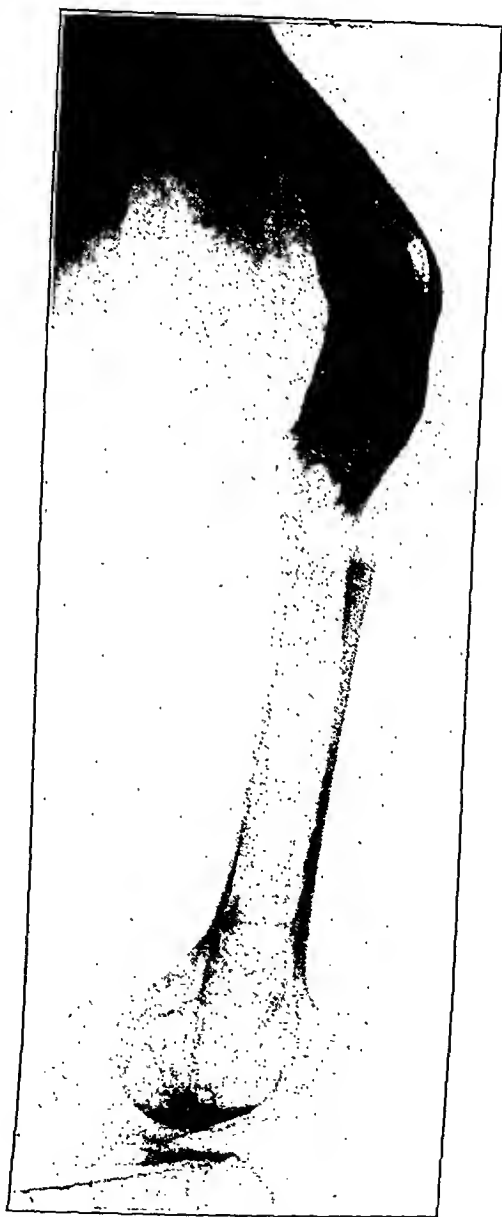


Fig. 7.—Anteroposterior view of the right femur (Case 3). The thin cortex and wide medullary cavity with the irregular striations are most striking. This x-ray was made shortly after the occurrence of the fracture shown and the rarefaction of the bone is not the result of disuse atrophy. A number of healed fractures are also seen in the more proximal portion of the femur.

actually appears to have been decreased. This agrees somewhat with Bookman's suggestion that calcium retention is subnormal in this disease.

The values for blood calcium and phosphorus, as determined in two of the cases presented here, compare favorably with those submitted by

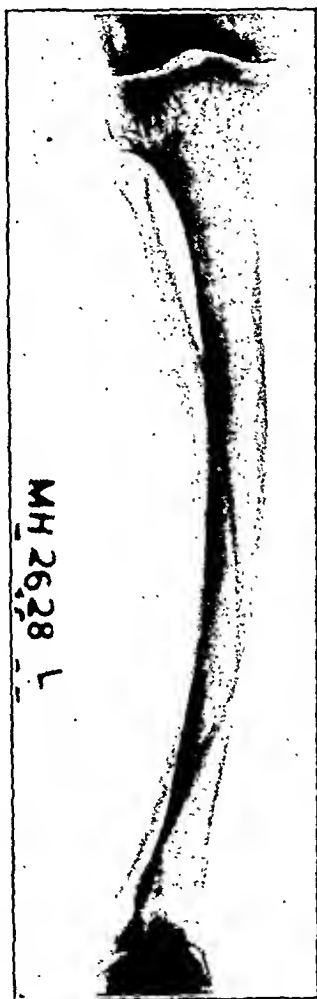


Fig. 8.—Tibia and fibula from Case 3, showing the thin cortex and wide medullary cavity with linear striation of the bone. The bowing is compensatory to the distorted femur.

Gregory and Andersch in the instance of the normal and are in no way related to the values they obtained in the cases of hyperparathyroidism.

The conclusion to be drawn from these chemical studies is that the pathology of osteopsathyrosis is not related to the general calcium and phosphorus metabolism.

PATHOLOGY

Observed at the time of operation, the femur of Case 3 was a yellowish-gray color with a rough irregular surface, the whole appearing more like a bundle of fine spicules than solid bone. The medullary cavity contained a pale yellow fatty material which melted on pressure. There was practically no bleeding from the cut surface of the bone.

According to Wagoner, who studied the amputated leg of an osteopsathyrotic, the fresh specimen was spongy in appearance, the periosteum ragged, the cortex thin and friable, and the marrow soft, edematous, and fatty. The histologic examination showed that the



Fig. 9.—Pelvis and upper femurs of Case 3, showing multiple healed fractures of both femurs. The thin cortex and wide medullary cavity are shown. From the x-ray viewpoint the structure of the femurs and pelvic bones is very similar. The ground-glass density is striking.

periosteum was slightly thickened but in general presented a normal structural appearance. Its outer layer was densely fibrous and its inner portion somewhat more cellular and vascular. The internal coats of a few small arteries were thickened. The osteogenic layer was inconspicuous and appeared unproductive. The cortex did not form a continuous ring but was broken into large and small segments, which showed marked distortion of the Haversian canals and concentric lamellae. Many canals were extraordinarily large and appeared to be filled with marrow substance. In contrast, other canals were small, narrow, and apparently compressed. The bulk of the sections was com-

posed of loosely arranged bony trabeculae which simulated spongy bone and branched throughout the medullary cavity. These trabeculae intermingled with islands of compact bone. Between them were irregular marrow spaces occupied by a delicate stroma containing myxedematous substance in which were a few fat cells, a moderate number of round cells, and many small blood vessels. Closely approximating the islands of compact bone were small groups of multinucleated osteoclasts. Rows of osteoblasts clothed the majority of osseous trabeculae.

The microscopic picture of the bone removed from Case 3 agrees closely with that described by Wagoner. A portion of a section shows what appears to be normal bone surrounded by an osteogenic zone in which the osteoblasts show activity. Adjacent to the spicule of normal appearing bone the structure is that of a rather atrophic fibrous connective tissue. Nowhere is there evidence of the lamellar structure normally seen in cortical bone.

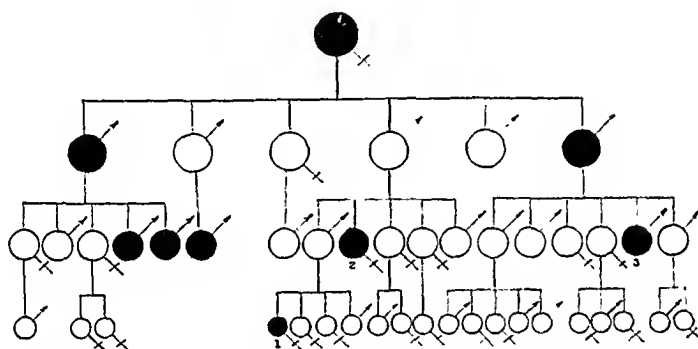


Fig. 10.—Genealogic table. The darkened circles indicate members of the family with fragile bones. Numbers 1, 2, and 3 correspond with the cases reported.

DISCUSSION

Practically, it is impossible to trace the transmission of bone fragility as a genetic factor in the human family. Deductions can be made only from evidence as it appears. When more exact knowledge of the influence of endocrine secretion on bone structure is available, deductions will be more accurate. This must have been the thought of Voorhoeve when he described the etiology of osteopsathyrosis as "an inherited inferiority of the mesenchyme." Terry showed evidence of heredity in 9.8 per cent; Griffith, in 26 per cent; and myself in 25 per cent of the cases studied. It has sometimes appeared that osteopsathyrosis is transmitted as a sex-linked factor. Hanson and Griffith have said that the factor for bone fragility may be readily transmitted from the first to the third generation through an unaffected female. Transmission through two unaffected individuals occurred in the family presented here, while other members of the same generation were affected; but

contrary to Hanson and Griffith's experience the unaffected members were the father and grandfather of the child, Case 1. (See family tree for indications, Fig. 10.)

Conrad and Davenport stated that the factor which determines imperfect brittle development of the bones in osteopsathyrosis is a simple dominant one. It is equally facile to show that, if the condition is due to a genetic factor, it may be heterogeneous or a recessive one. At this point it must be recalled that in approximately 75 per cent of the instances, the condition appears idiopathically and that unequivocal cases have appeared in practically every race and nationality. Caucasians predominate but negro cases are not infrequent and a case is reported in a pure American Indian. Peculiarly, the condition seems to be self-limited in that after four generations it vanishes as suddenly as it came.

It appears that other factors besides the gene for bone development must be responsible for this disease.

According to Bronson, in 1900, Eddows associated blue sclera with bone fragility. Since that time all too many cases have been diagnosed osteopsathyrosis by the observance of blue sclera in a patient with a history of one or more fractures. Griffith reviewed 67 cases without mention of blue sclera. In 50 cases of osteopsathyrosis reviewed by myself, blue sclera was found in 72 per cent of the patients. There is a noticeable azure blue color of the sclera of Case 1 in this paper. On the other hand, blue sclera may occur more frequently than has been recorded. Ruggeri quoted Burrows, who described a family of 29 individuals in four generations, 14 of whom had definitely blue sclera, but only 7 had evidence of bone fragility. Ruggeri also quoted Drighthon, who found a family of 14 individuals in four generations, 9 of whom had blue sclera and of these only 5 had fragile bones.

Numerous attempts have been made to explain the source of the blue sclera. Bronson cited Buehanau who in 1908 made a histologic study of eyes with blue sclera. He described the cornea as being three-fifths as thick as normal and the sclera one-third the usual thickness. He found a decrease in the total amount of fibrous tissue of the sclera but no change in the individual fibers. Later, Muir and Patterson stated that in their opinion the blue sclera was of normal thickness, but transluence was increased, allowing the dark choroid layer to be perceptible.

The evidence available does not permit one to admit more than the fact that blue sclera is frequently observed in cases of osteopsathyrosis.

There are also a number of physical abnormalities in addition to blue sclera which have been frequently described as part of this disease. Bronson, Terry, Stewart, Wagoner, and others have pointed out the deafness which is seen in some of these patients. Statistics, however, show an incidence of only 8 per cent. The nature of this deafness has been poorly defined. Fraser stated that it is the result of deposition of

calcium in the middle ear. It has also been suggested that in many instances there is pressure on the eighth nerve somewhere in its course through the thickened irregular temporal bone.

Bronson called attention to the prominent frontal and occipital bones of the osteopsathyrotic skull but definitely contrasted this deformity with the square, box-shaped skull of the rachitic. Thin fontanels frequently persist late in life and the suture lines are prominent. The heads of new bone osteopsathyrotics have been described as "bags of bones with eggshell thickness."

The exophthalmus present in some osteopsathyrotics has no significance other than secondarily to the contour of the skull. It is difficult to establish poor dentition as part of the disease. Many osteopsathyrotics have been said to have infantile genitals, but the cases I have seen showed no such abnormality. However, it is questionable whether or not it is possible for an osteopsathyrotic mother to deliver a living child if her pelvis is of the flattened shallow type.

TREATMENT

The treatment of fracture or dislocation occurring to an osteopsathyrotic is no different from that in a normal person. In most instances healing occurs very rapidly with the formation of abundant callus. Poor reduction and fixation of fractures are the causes of most of the distortion of the bones. So frequently have some of these patients had fractures and dislocations that they learn to treat their own injuries by simple splinting after restoration of the contour of the injured bone.

The administration of calcium, phosphorus, cod liver oil, and various extracts has not produced any effect on the structure or fragility of the osteopsathyrotic bone. Henderson injected thymus gland extract (Hanson) in two cases, but he was not able to demonstrate a change in bone structure. Hanson's thymus extract is being used in the treatment of Case 1 at present.

SUMMARY

Osteopsathyrosis is a disease of the skeleton characterized by marked fragility. It apparently is inherited, although the manner of genetic transmission is not evident.

The x-ray and microscopic pictures of the bones are relatively constant and unlike any other pathologic entity.

There is no biochemical evidence to show that the disease is related to pathologic calcium or phosphorus absorption and retention.

Blue sclera frequently, though not constantly, appears in osteopsathyrosis.

Treatment of fractures of osteopsathyrotics is the same as that for normal individuals. Rapid healing with abundant callus is the rule.

The administration of various drugs, vitamins, and extracts has not been demonstrated to affect the growth or structure of the bone in this disease.

Three cases of osteopsathyrosis treated at the Medical College of Virginia Hospitals are presented.

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RUPTURE OF THE ESOPHAGUS IN A CHILD TWO YEARS OF AGE, WITH RECOVERY

CLIFFORD D. BENSON, M.D., AND GROVER C. PENBERTHY, M.D., DETROIT, MICH.

(From the Surgical Service of the Children's Hospital of Michigan)

RUPTURE of the esophagus is usually a fatal accident, death resulting in twenty-four to forty-eight hours from a fulminating mediastinitis and pleuritis. The site of rupture is practically always just above the diaphragm, and, from the published reports, the left lateral wall is more prone to this accident than the right. It has been emphasized by McKenzie¹ that this is the weakest portion of the esophagus.

According to Boerhaave,² Baron Wassenau died from a spontaneous rupture of the esophagus in 1724. Spontaneous rupture has been found mainly in adults, but Menne and Moore³ in 1921 reported such an accident in an infant of 5 months of age, following repeated vomiting. The rupture occurred 1 cm. above the cardia, and there was collapse of the left lung with some spilling of the esophageal contents into the left pleural cavity. Many observers have strongly contended that spontaneous rupture of the esophagus occurred because of preceding inflammatory changes in the wall of the esophagus. Williams and Boyd⁴ (1926) concluded from their studies on dogs that this opinion was justified. Brosch⁵ concluded that spontaneous rupture of the esophagus would occur following vomiting (which act causes increased intra-esophageal pressure), or, secondarily, from digestion of the esophageal wall by the gastric juice, causing ulceration. Murdoch⁶ reported a rupture of the esophagus due to indirect violence; the patient was a child who had been run over by a motorcycle. At post mortem, the rupture was found $\frac{3}{4}$ inch above the diaphragm, with the left lung collapsed and a small amount of fluid present in the left pleural cavity.

Rupture of the esophagus secondary to direct trauma, such as instrumentation, has been a serious complication which is usually followed by fulminating mediastinitis and death. Perforations, either small or of gradual onset, have been known to recover without surgical intervention. Ballin and Saltzstein⁷ in 1922 reported a perforation of the esophagus, resulting in a right-sided empyema. This was treated by drainage, with rib resection, and ultimate recovery occurred.

The following case report is that of a child admitted to the Children's Hospital of Michigan because of difficulty in swallowing:

The administration of various drugs, vitamins, and extracts has not been demonstrated to affect the growth or structure of the bone in this disease.

Three cases of osteopsathyrosis treated at the Medical College of Virginia Hospitals are presented.

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This finding of tension pneumothorax with fluid in the pleural cavity led us to suspect that the esophageal ulcer had perforated into the left pleural cavity. Fluoroscopic examination at 9:00 P.M. revealed that there was a total collapse of the left upper lobe and 50 per cent collapse of the left lower lobe, with marked displacement of the heart to the right. The child was placed in an oxygen tent with no apparent improvement. Because of the increase in the severity of the tension, pneumothorax, and the inability to control it by aspiration, it was deemed advisable at 11:00 P.M. to institute a closed catheter type of drainage under water. This resulted in marked relief of the dyspnea and cyanosis. Unknowingly, a student

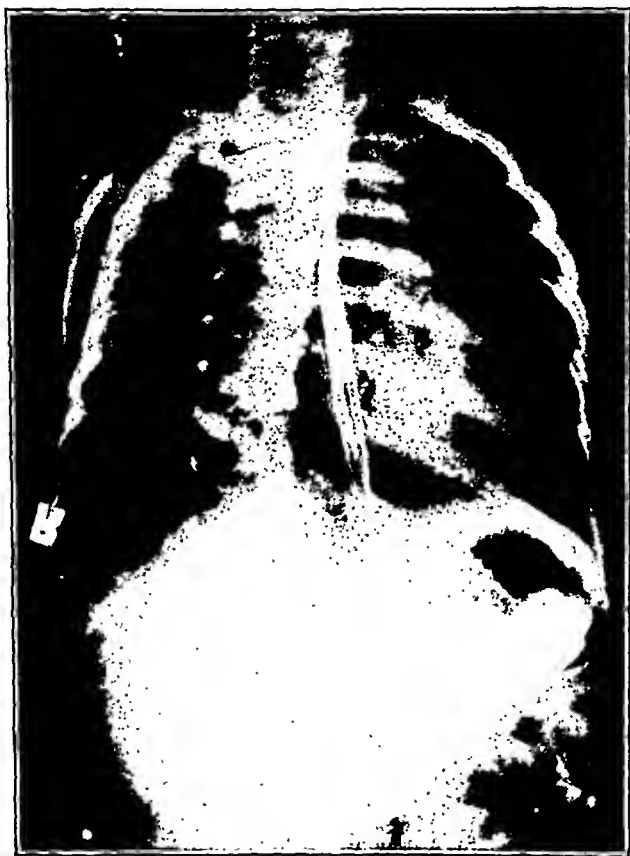


Fig. 2.—Small amount of barium given and x-ray taken approximately 2 months after rupture of lower end of esophagus.

nurse gave the child milk to drink, and immediately the milk appeared in the drainage tube which had been placed in the left pleural cavity. This definitely proved that there was a perforation of the esophagus into the left pleural cavity. A Levine tube was inserted into the stomach for feeding purposes, putting the esophagus at rest. Fluoroscopic examination and an x-ray film Aug. 8, 1935, showed the drainage tube in the left pleural space, with no indication of free air or fluid in the left pleural cavity. The rectal temperature varied from 102° to 104° for two days following the rupture of the esophagus. Aug. 15, 1935, x-ray examination revealed the lung almost completely re-expanded. The Levine tube was used for feeding purposes until Aug. 20, 1935, when fluids were given by mouth. The fluid which drained

C. B., white male, 2 years of age, entered the hospital on Aug. 6, 1935, with a history of having been well until July 30, 1935. The swallowing of a foreign body on the date was suspected. It was reported that, previous to admission to the hospital, the child had eaten very little and had vomited repeatedly since the onset of symptoms. Physical examination revealed a well-nourished white male of 2 years, appearing dehydrated. His temperature was normal; pulse, 110; respirations, 24. The fontanelles were closed; pupils were equal and reacted to light; ears and nose, negative; tongue, dry; and the throat, slightly injected, but no foreign body was seen. There was no rigidity of the neck, but on examination of the chest, an oc-

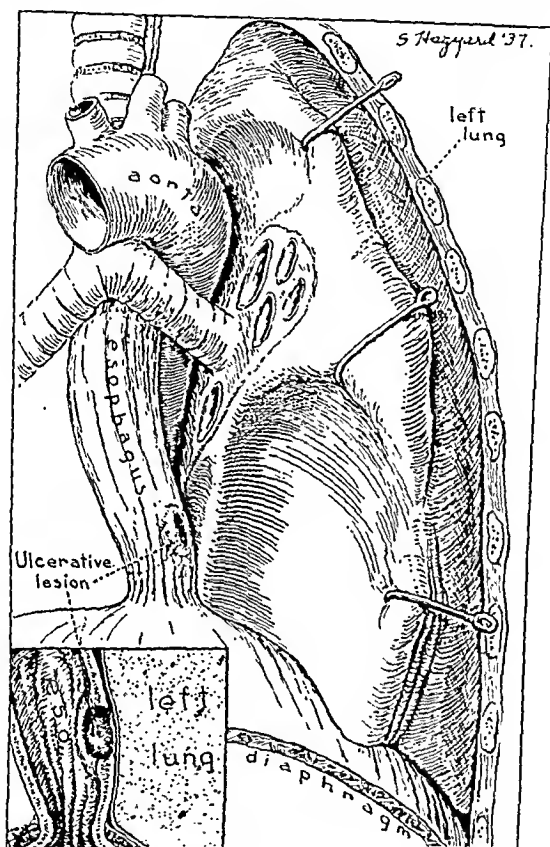


Fig. 1.—The authors' conception of the location and type of rupture of the esophagus.

casional coarse râle was heard over both bases. The heart borders were normal, and no murmurs were heard. The abdomen was soft; liver and spleen were not palpable. A diagnosis of suspected foreign body in the esophagus was made. On Aug. 7, 1935, the patient was esophagoscoped by Dr. A. E. Hammond, who found no evidence of a foreign body in the esophagus, but did see an ulcer approximately 1 by 1 cm. in the left lateral wall, about 1 inch above the cardia. The floor of the ulcer was necrotic and surrounded by a zone of hyperemia. After this examination, the child strained considerably and vomited. Approximately four hours later, there were signs of a left tension pneumothorax, which was aspirated, 400 c.c. of air and 20 c.c. of serosanguineous fluid being removed, with marked relief of the dyspnea.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

PROGRESS IN SURGERY OF THE AUTONOMIC NERVOUS SYSTEM

JAMES C. WHITE, M.D., BOSTON, MASS.

(From the Surgical Services of the Massachusetts General Hospital)

THE intrusion of neurosurgery into the field of cardiovascular and other forms of visceral disease has been so dependent on contemporary investigations of the fundamental laboratory sciences that the compiler of a review of recent surgical progress must include much of the current work in neuroanatomy and physiology. For this reason, no apology is due for incorporating a large proportion of papers which at first glance might seem to be more suitable to a journal devoted to special laboratory investigation. Similar reviews of advances in surgery of the autonomic nervous system have appeared annually in the *New England Journal of Medicine* since 1930;¹ the reader who is interested in a summary of the principal papers which have appeared in preceding years may refer to them.

ANATOMY AND PHYSIOLOGY

Recent work of far-reaching importance has given an insight into the way the involuntary nervous system adapts the body to emotional and physical changes. Investigation of the activity of higher centers in the cerebral cortex has been carried out by the Department of Physiology at Yale and has been summarized by Fulton.² He points out that the activity of structures, such as the heart, blood vessels, gastrointestinal tract, and secretory organs, are immediately subject to integrations occurring at the cortical level. As early as 1876, Hughlings Jackson³ had suspected that visceral functions must have extensive representation in the cerebral cortex, since these functions are almost invariably disturbed during epileptic seizures emanating from this level. Little was done to verify Jackson's hypothesis until the last few years. The systematic investigation of Fulton and his colleagues by stimulation and ablation of cortical areas in the cat, dog, and monkey has demonstrated that the principal areas in which autonomic responses have been obtained on stimulation overlap those giving somatic reactions. It is clear that the frontal lobes, and in particular those areas known in the cyto-

¹Received for publication, October 3, 1938.

through the catheter showed no growth on culture. Aug. 26, 1935, the tube was removed from the pleural cavity and the child was discharged from the hospital four days later. Check-up examination and fluoroscopic study Sept. 30, 1935, when a small quantity of barium suspended in milk was given, showed that there was no interruption in the downward progress of the barium into the stomach. The lumen of the esophagus was reported small, but there was no abnormality in the contour of this structure at the site of the reported previous rupture. May 24, 1937, or twenty-one months after the rupture, there were no symptoms referable to the esophagus or thoracic organs. Fluoroscopic examination after the administration of barium revealed no evidence of obstruction or stricture in the esophagus.

McKenzie¹ has emphasized that the weakest point in the esophagus is just above the diaphragm. This anatomic weakness predisposes to rupture in this portion of the esophagus. The case herein reported had an ulcerative lesion present which made rupture easy following vomiting and straining. Boyd and Williams,⁴ as quoted by Gott,⁸ urged early surgical drainage of the pleural cavity. Gott⁸ (1933) reported four cases of spontaneous rupture of the esophagus, one of which had a thoracotomy performed on the tenth day, and expired on the seventeenth day of illness.

We believe that rupture of the esophagus must be considered in all cases of sudden collapse following instrumentation of the esophagus, indirect violence to the thorax or abdomen, or repeated vomiting. If this lesion is suspected, the esophagus should be put at rest by carefully inserting a Levine tube for feeding purposes and early drainage of the pleural cavity instituted by the closed catheter method. Radical surgery by immediate thoracotomy and suture has been reported as futile.

CONCLUSIONS

1. A rupture of the esophagus in a child 2 years of age, with recovery, is reported.

2. Preceding local disease of the esophagus predisposes to spontaneous rupture following vomiting.

3. Patients in whom prostration, dyspnea, substernal pain, subcutaneous emphysema of the neck occurs should suggest esophageal rupture.

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architectural maps as areas 4 and 6, are regions in which integrations occur simultaneously in both the autonomic and somatic spheres. Thus, when a vigorous volitional movement occurs, the muscles involved may be supplied automatically with an increased amount of blood, the reaction occurring as a direct innervation from the cortex, rather than as a secondary response to local accumulation of metabolites. The studies of Hoff and Green^{4, 5} on curarized animals indicate that, when the premotor cortex is stimulated, the muscles affected show an increased volume which can only be due to an increased flow of blood through them. The overlying skin exhibits little change. When limb volume increases, that of a viscus like the kidney is diminished. Furthermore, during vigorous skeletal movement the cortex through its gut representation is capable of directly shifting the blood from the visceral to the muscular bed and inhibiting the activity of the gut. On the basis of these experiments, it is concluded that a mechanism exists by which the requirements for increased blood supply in muscles brought into action by the motor cortex may be anticipated.

These newer disclosures concerning the relation of the cerebral cortex to the autonomic nervous system give an adequate physiologic basis for the long-recognized relationship between mental states and visceral processes. It is thus clear that the load which is placed upon the circulatory system may be determined in large measure by the mental state of the individual. In emphasizing this point, Fulton aptly states that "the heart and circulation may be worked just as hard, and just as much as a detriment to the body as a whole, from an arm chair—or perhaps I should say a swivel chair—as from a rower's seat." As Cannon⁶ has pointed out, many disturbances of the thyroid, cardiovascular, and gastrointestinal functions undoubtedly have a similar basis. In résumé, it seems highly probable that with more thorough analysis all autonomic functions will be found to be to a certain extent under cortical control.

The work of many physiologists and clinicians, which has been summarized in previous reviews of progress in this field,¹ has resulted in a corresponding advance in knowledge of the functions of the hypothalamus. As stated by Papez,⁷ not only areas 4 and 6 on the lateral surface of the cerebral hemispheres, but also the medial cortex in the region of the gyrus cinguli and the hippocampal formation have important connections with the hypothalamus and the anterior thalamic nuclei. It is these related areas which probably elaborate the functions of central emotion and give rise to emotional expression. This integration meets the physiologic requirements proposed by Cannon⁶ and Bard⁸ in respect to the theory of corticodiencephalic processes. It is also in agreement with the observations of Dandy⁹ that the seat of consciousness is located somewhere near the midline, between the limits set by the corpus callosum and the basal structures of the brain.

The evidence that the hypothalamus contains the central ganglia of the autonomic nervous system is well summarized in Ranson's Harvey Lecture.¹⁰ He shows that the hypothalamus exerts its important regulatory functions through two channels. By way of the hypothalamico-hypophyseal tract it controls secretion of the antidiuretic hormone from the posterior lobe of the hypophysis and thereby the rate of elimination of water through the kidneys. The interruption of this tract results in atrophy of the pars nervosa and causes diabetes insipidus. Secondly, through its connections with the rest of the brain and spinal cord, the hypothalamus regulates visceromotor activity. When released from cortical inhibition, as in Bard's decorticate cats, or when stimulated electrically in Ranson's and in Beattie's¹¹ experiments, the hyperactivity of these centers causes dilation of the pupils, bristling of the hair, elevation of the blood pressure, and on the somatic side rapid respiration, struggling, clawing, and biting; in other words, the picture of emotional excitement. Conversely, damage to the hypothalamus produces emotional stolidity and somnolence. Working at least in part through the sympathetic nervous system, the hypothalamus serves also as a thermostat in the regulation of body temperature. After anterior lesions, cats tend to develop postoperative hyperthermia and are unable to protect themselves against rising external temperatures. After posterior lesions the animals run subnormal temperatures and are easily chilled. Possibly through injury to the descending pathway from the anterior hypothalamus, these animals are also unable to protect themselves against overheating and become truly poikilothermous.

Similar alterations in the temperature regulation of human beings have been observed in tumors which infiltrate the hypothalamus. Davison and Friedman¹² report a child with destruction of the hypothalamic nuclei by an infiltrating neuroblastoma who showed extreme temperature fluctuations from 103° to 93°. Other cases cited by Davison and Friedman have been described in recent years, and Peet and Kahn¹³ have observed extraordinary vasomotor changes in the extremities in patients with lesions in this area. Indeed, it is highly probable that states of chronic vasoconstriction (Raynaud's disease) and hyperhidrosis ultimately will be connected with abnormal hypothalamic function.

A final point of interest in connection with stimulation of the hypothalamus is the report of Magoun, Ranson, and Hetherington¹⁴ that large amounts of adrenaline and sympathin are liberated in the blood stream under these circumstances. This is of direct clinical importance in relation to the residual ability of smooth muscle to contract after denervation.

In a monograph entitled *Autonomic Neuro-Effector Systems* Cannon and Rosenblueth¹⁵ take up the discovery of acetyl choline by Loewi and of sympathin by Cannon and his co-workers. The authors trace the development of this new field of neurophysiology and its implications.

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indubitable evidence of complete regional sympathectomy. The fact that smooth muscle of the arterial walls becomes some ten times more sensitive to circulating adrenaline and sympathin after degeneration of its postganglionic fibers* and but three times more sensitive if only preganglionic fibers are cut has been most clearly demonstrated by Ascroft.²¹ Previous, less carefully controlled experiments by Grant,²² and by White, Okelberry, and Whitelaw²³ have been in close agreement. White²⁴ had first pointed out that, inasmuch as the synapses between the pre- and postganglionic neurones occur in the inferior cervical and upper two or three thoracic ganglia in the case of the hand and in the lowest lumbar and upper two sacral ganglia in the case of the foot, resection of the second and third lumbar ganglia is a preganglionic sympathectomy; whereas, cervicothoracic ganglionectomy causes degeneration of the entire postganglionic network to the arm. This concept that an excessive sensitization to chemical mediators in the circulating blood is responsible for the poor results of cervicothoracic sympathectomy has been upheld by Cannon,¹⁷ Telford,²⁵ Learmonth,²⁶ and Ascroft.²¹ Ascroft has gone one stage further and shown in monkeys that the results of a previously satisfactory lumbar ganglionectomy can be vitiated if the sacral ganglia are subsequently resected.

This peculiar reaction of the denervated vascular wall to adrenaline, sympathin, and possibly to other chemical substances in the circulating blood therefore must be taken into account. Normal vessels react slightly to adrenaline, but after any form of sympathectomy this effect becomes exaggerated. This can be noted within twenty-four hours of denervation and reaches its maximum between the tenth and fourteenth days. The degree of sensitization then persists at about this level unless regeneration occurs. If this takes place, the heightened response subsides (Simeone²⁷). Fortunately sensitization is a clinical handicap only after postganglionic sympathectomy. If care is taken to interrupt the peripheral vasoconstrictor pathway only in its preganglionic component, a most satisfactory vasodilation results and is maintained.

Standardized technical procedures are now available which fulfil these physiologic requirements:

Lumbar Ganglionectomy.—For the relief of vasospasm in uncomplicated Raynaud's disease of the lower extremity, resection of the second and third lumbar ganglia can be counted on to produce effective and lasting vasodilation. Since the fourth lumbar ganglion gives off a few postganglionic fibers to the sciatic nerve, it is best to leave it in place.

*For those who do not understand the terms pre- and postganglionic, it may be stated that there are two sets of fibers in the peripheral sympathetic pathway. The upper or preganglionic fibers have their cells of origin in the lateral horn of gray matter in the thoracic and upper two lumbar segments of the spinal cord. Their axones pass by way of the anterior nerve roots and white rami communicantes to the paravertebral sympathetic chains, in which they run cranially or caudally for varying distances before forming synapses with other ganglion cells. From the latter, lower or postganglionic axones arise, which pass to the brachial and lumbosacral plexuses in the gray rami communicantes. These lower axones run in the mixed nerves to the peripheral vascular tree.

Of greatest practical concern to the surgeon is the finding that smooth muscle is rendered abnormally sensitive to circulating adrenaline and sympathin, a fact first observed by Meltzer and Auer¹⁶ in 1904 and then nearly forgotten until the recent revival of interest in chemical transmission of the nerve impulse. The experiments which established this fundamental principle have been reviewed in Cannon's George E. Brown Memorial Lecture¹⁷ before the American Heart Association and in the recent review of "Advances in Sympathectomy for Peripheral Vascular Disease" by Peyton and Titus¹⁸ which recently appeared in this JOURNAL, as well as in previous articles in this series.¹⁴⁻¹⁶ Suffice it to point out here that the sensitization phenomenon is found in all smooth muscle which is under the control of adrenergic nerve impulses, and that its effects have been measured on the denervated heart and nictitating membrane,¹⁵ as well as on the peripheral vascular tree. McCloskey, Co Tui, Mulholland, and Wright,¹⁹ have found that its action may become so intense as to produce necrosis of the skin when adrenaline is injected intracutaneously in the lower forelimb of a dog after stellate ganglionectomy. The impossibility of producing a chronic flaccid form of paralysis in smooth muscle is explained in large part by this sensitization to chemical mediators which are liberated in the circulating blood whenever the sympathetic nervous system is called into activity. Whether there is another gland of internal secretion (for example, the posterior lobe of the pituitary or the adrenal cortex) which supplies a chemical agent that might account in part for the restoration of tone in sympathetomized smooth muscle is not known. Since Govaerts²⁰ experiments, it is also established that the peripheral sympathetic ganglia, after their central connections have been cut, develop a rhythmic discharge of their own. Cannon¹⁷ feels that restoration of tone after denervation must result in part from an intrinsic property of smooth muscle itself, because it is found in the completely sympathetomized animal.

OPERATIVE METHODS

A better understanding of the puzzling discrepancy in results following sympathetic ganglionectomy of the upper and lower extremities has resulted from the explanation of the peculiar behavior of smooth muscle after denervation. It has been pointed out in the preceding section that there is always a considerable restoration of tone in any form of denervated smooth muscle. This has been found to vary in degree with the level at which the central or peripheral pathway is cut. Whereas lumbar ganglionectomy has given consistent relief of vasospasm in patients with Raynaud's disease of the lower extremity, careful follow-up examinations after resection of the inferior cervical, first and second thoracic ganglia frequently have shown a striking degree of residual vasospasm on exposure to cold or excitement, even in patients with

tone which results from the preganglionic operation, another advantage is that the ocular fibers are not interrupted and thereby the patient is spared the disfiguring ptosis, pupillary constriction, and enophthalmos of a Horner's syndrome.

In summarizing these important findings in the field of peripheral vascular disease, it seems fair to conclude that there is no occasion to question the general physiologic principle of the sensitization phenomenon which appears with the denervation of all smooth muscle. The increased sensitization which follows postganglionic denervation also has been fully corroborated by many different investigators. Whether the present surgical methods for accomplishing this type of sympathectomy are fully satisfactory, time alone can tell.

EFFECTS OF SYMPATHECTOMY ON CIRCULATION

Carotid Sinus Syndrome.—Heymans and Brouha³³ have contributed a very complete review of the reflex control of circulation by the carotid sinus and the cardioaortic nerves. One important function of this mechanism is to assure an adequate flow of blood through the vital centers of the brain, which are so easily damaged by lack of oxygen. These investigators not only have found that vasopressor and depressor reflexes originate from these plexuses in the vascular walls, but also they describe other accessory vascular reflex centers in the splanchnic area. All of these give off impulses to the higher vasomotor centers when they are stimulated by alterations in either the blood pressure or the chemical content of the circulating blood.

A further clinical study of the carotid sinus and other sensitive areas in the periphery which may set up visceral reflexes has been contributed by Ferris, Capps, and Weiss.³⁴ These authors find that surgical denervation of the carotid sinus does not alter visceral symptoms in patients with vegetative neuroses, and that in these states many other parts of the body may become conditioned as reflex centers so that their stimulation may produce a great variety of symptoms and signs. Such areas as the eyeball, pharynx, larynx, bronchus, pleura, esophagus, and arteriovenous aneurysms have been cited as examples of sensory stations which under abnormal conditions can influence efferent portions of the autonomic nervous system in the same manner as the hypersensitive carotid sinus. With the realization that other peripheral areas may send afferent stimuli to the central ganglia of the autonomic nervous system, it becomes obvious that the carotid sinus alone cannot play a major role in regulating the tonus of the autonomic nervous system. Mechanical stimulation of an irritable sinus, however, can produce three well-recognized syndromes: (1) periods of bradycardia or asystole; (2) transient falls in blood pressure; and (3) syncopal attacks and epileptiform convulsions.

In patients with Buerger's disease, where it is desirable to produce the maximum vasodilation in the upper leg as well, Fontaine, Honot, and Dos Santos²⁸ have given clear-cut experimental evidence that the resection should be carried upwards to include the first lumbar ganglion. When this is done, the male patient should be warned that he will become sterile through loss of the power of ejaculation.

Lumbar ganglionectomy is best carried out by the posterior extraperitoneal approach. Excellent modifications of Royle's original muscle-splitting incision have been worked out by a number of surgeons and are described by Pearl.²⁹ These permit exposure of the entire length of the lumbar chain from its first to fourth ganglia. Even if a bilateral resection is to be undertaken, the consensus of recent opinion has favored a two-stage extraperitoneal approach over the older transperitoneal incision because of its increased safety and the smoother convalescence.

Thoracic Sympathectomy for Preganglionic Denervation of the Upper Extremity.—Two operative procedures recently have been advocated which have given most satisfactory results in the hands of their originators. That of Smithwick³⁰ consists of a posterior paravertebral approach with resection of the medial portion of the third rib and corresponding part of the transverse process. The sympathetic trunk is divided caudal to its third thoracic ganglion and its cephalic end swung up and buried in the intercostal muscles. As a few more rostral vasomotor fibers emerge over the second and third intercostal nerves, these also must be divided. The secret of success in this operation depends on a careful central dissection of these nerves down to the intervertebral foramina and on making sufficient traction so that they can be cut off central to their point of division into anterior and posterior roots. If this point is neglected, a few rami to the brachial plexus are usually left intact and some residual vasoconstriction and sweating from central impulses is almost certain to persist.

The operation devised by Telford³¹ and now widely used in England utilizes the cervical approach of Gask and Ross.³¹ After cutting across the anterior scalene muscle, the apical pleura is freed from the sides of the vertebrae as far down as the third rib. The rami communicantes which connect the second and third thoracic ganglia to the corresponding intercostal nerves are then divided and the sympathetic trunk cut below the third thoracic ganglion. The crucial step here is to swing the cephalic portion of the chain up as far as possible and to bury its end in one of the cervical muscles. Preganglionic fibers have an extraordinary capacity for regeneration and the two divided ends of the chain must be widely separated. In his earliest cases Telford neglected to carry out this step, with the result that Simmons and Sheehan³² observed a gradual return of sweating and vasoconstriction in three patients within six months. In addition to the diminished degree of residual vasoconstrictor

ing the process and encouraging repair." In Group 8 sympathectomy is being found to be of increasing value.

Lewis³⁸ has always contended that Raynaud's disease is due to a primary fault in the smooth muscle of the digital arterioles with local susceptibility to cold. This is undoubtedly true in the cases of Group 2, where nutritional changes have developed local fibrosis and often actual endarteritic changes in the digital arteries. Whether Lewis's contention is correct that vasoconstrictor activity is not increased to an abnormal degree in cases under Group 1 remains to be proved. Opinion in this country has been that in the early uncomplicated stage of the disease sympathetic tone is abnormally high. Evidence in support of this has been summarized by Adson.³⁹

The controversy between those who believe that poor results of sympathectomy in the upper extremity are due to incomplete denervation and those who feel that an unphysiologic operation (postganglionic denervation) is the principal factor has not been fully settled. Certainly other factors play a role, such as the tendency for the disease to be more severe in the hand than in the foot, and the fact that vasoconstrictor tone is greater in the lower extremity (Doupe, Robertson, and Carmichael⁴⁰).

The results of preganglionic sympathectomy in Raynaud's disease of the upper extremity, when properly performed, speak strongly in favor of the second of the two theories mentioned in the preceding paragraph. Perhaps the most convincing argument to bring out the importance of interrupting vasoconstrictor impulses in the upper preganglionic axone has been presented by De Takats.⁴¹ He reports observations on four patients suffering from Raynaud's disease, in whom preganglionic sympathectomy had been performed on one side and postganglionic on the other. The contrast between the two sides was striking. Out of four preganglionic sections, his results were excellent in three and only fair

TABLE I
RESULTS OF SYMPATHECTOMY IN RAYNAUD'S DISEASE
SIXTEEN SYMPATHECTOMIES ON SIX PATIENTS*

| CASE NO. | NAME | DURATION | OPERATION | RESULT | REMARKS |
|----------|-------|----------|----------------|-------------|--------------------------|
| 1 | W. F. | 3 yr. | Preganglionic | 1 Fair | 1 |
| | | | Postganglionic | 1 Failure | 1 |
| 2 | N. S. | 8 yr. | Postganglionic | 2 Failure | 2 Residual sweating |
| 3 | A. M. | 6 yr. | Preganglionic | 1 Excellent | 3 |
| | | | Postganglionic | 1 Failure | 1 |
| | | | Lumbar | 2 | Brachial neuritis, 6 wk. |
| 4 | A. J. | 1 yr. | Preganglionic | 1 Excellent | 1 |
| | | | Postganglionic | 1 Fair | 1 |
| 5 | P. Z. | 10 yr. | Preganglionic | 1 Excellent | 1 |
| | | | Postganglionic | 1 Fair | 1 |
| 6 | K. S. | 8 yr. | Postganglionic | 2 Fair | 2 |
| | | | Lumbar | 2 Excellent | 2 |

*Patients in this series have been followed through at least one winter, three of them through two winters. By fair result is meant definite improvement, fewer or shorter attacks, but not complete relief.

Weiss, Capps, Ferris, and Munro³⁵ have shown that in the first two conditions medication with atropine and ephedrine is sufficient to prevent vagal and vasodilator reflexes. Only the third variety of abnormal response may require surgical intervention. Freedberg and Sloan³⁶ have described four such cases, in two of which lasting freedom from the convulsive seizures was secured by denervation of the irritable zone at the carotid bifurcation. In the other two the attacks could be stopped by novocainization of this area, but no operation was carried out. Robinson's³⁷ recent finding that the tendency to this form of syncope and convulsions can be relieved by benzedrine sulfate deserves a careful trial and may save this group of cases from the need of surgical denervation.

Raynaud's Disease.—In planning sympathectomy for patients with vasospasm the surgeon must never forget that the term Raynaud's syndrome includes a number of pathologic conditions. These were listed by Lewis and Pickering and have been discussed in detail by Lewis³⁸ in his monograph on vascular disorders of the limbs:

- "1. Intermittent spasm of digital arteries, without complications.
- "2. Intermittent spasm of digital arteries, with local nutritional changes.
- "3. Intermittent spasm of digital arteries, with generalized scleroderma.
- "4. Raynaud's phenomenon arising out of local injury, including the use of vibrating tools.
- "5. Bilateral gangrene of digits in the young, and with infection; this condition is regarded as probably the result of thrombotic closure of vessels.
- "6. Bilateral gangrene with haemoglobinuria from cold. . .
- "7. Bilateral gangrene of digits in the elderly, in which closure is shown to be thrombotic, but preceded by disease of the small arteries.
- "8. Thrombo-angiitis obliterans associated with Raynaud's phenomenon.
- "9. Cervical rib or crutch pressure causing Raynaud's phenomenon or gangrene . . . by thrombotic and embolic processes."

Learmonth,³⁹ in his excellent review of surgery of the sympathetic system, has stated that the possibility of treatment by sympathectomy arises in any of these conditions except 6, 7, and 9. He believes "that operation should be recommended in groups 1 and 2 if the attacks continue to be troublesome after the patient has placed herself in the best possible environmental conditions. In group 3 operation may be offered, but with less assurance of relief, for the vessels are too confined by new fibrous tissue. In group 4 change of occupation is imperative, and operation should not be offered or undertaken until this has been arranged for. Group 5 should be offered operation, with a view to limit-

About 40 per cent of patients remain comfortable and are able to return to full work.

About 25 per cent have relief of pain and their circulation is much improved, but insufficiently to permit a return to work.

About 25 per cent show no appreciable improvement.

About 10 per cent require amputation.

In addition, De Takats⁴¹ and Telford⁴² have reported follow-up observations in 32 patients. In Telford's 22 cases, all of which have been followed from three to six years, 16 remain well and the disease has made no further progress. The other 6 display some degree of deterioration and further evidences of the disease. Two have recurrent attacks of phlebitis and 4 have required some form of amputation. From these Telford concludes that the benefit from operation is due entirely to dilation of the collateral bed. In De Takats' opinion claudication will not improve following sympathectomy unless subsequent vascular exercises are capable of enlarging a very limited vascular bed. Also, the operation cannot be expected to ameliorate the intractable rest pain which accompanies a fixed vascular bed. Here the most useful surgical procedure is the crushing of the sensory nerves to the foot, as originally described by Smithwick and White.⁴³

No outstanding recent advances have been reported in connection with sympathectomy for various other conditions. The improvement of circulation in the cold, blue, partially paralyzed legs which may result from poliomyelitis is of considerable value in carefully selected cases (De Takats⁴¹). Scleroderma, when it is limited to the extremities with accompanying vasospasm, may show limited improvement.^{26, 31} The recent method of combining parathyroidectomy with sympathectomy is outside the scope of this review. In the treatment of the intractable forms of hyperhidrosis where the excessive sweating is limited to the palms and soles, sympathetic denervation of the sweat glands continues to be the only effective treatment. Excellent charts of the regions over which the sweat glands are paralyzed have been published by Roth.⁴⁴ Finally, in the treatment of the rheumatoid form of arthritis, which was widely advocated a few years ago, more careful investigation of the effects of sympathectomy has shown that improvement can be expected in only a very limited group of cases (Learmonth⁴⁵).

Hypertension.—Arterial hypertension is a clinical sign, not a disease. While its causes are varied, experience demonstrates that the patients in whom the cause is known and can be dealt with surgically are extremely rare. One of the most interesting varieties is caused by tumors of the adrenal medulla which secrete large quantities of adrenaline and thereby produce paroxysmal attacks of hypertension. Accounts of these in the literature are not new, but Beer, King, and Prinzmetal⁴⁶ have been able to demonstrate the excessive amount of adrenaline in the circulat-

in one in whom residual sweating indicated that denervation had not been complete. The comparatively poor results of the older cervico-thoracic operation are so well brought out in the table of De Takats' operative results that it is here reproduced as Table I.

Smithwick, who has probably had the largest operative experience in this field, is at present reinvestigating a series of 70 cases, some of which have been followed for three years. These are being studied by testing the absence of any rise in temperature after novocain injection of the ulnar nerve, paralysis of the sweat glands, and freedom from sudden alterations in the psychogalvanic responses and in blood flow through the fingers measured with the photoelectric cell. With a very few exceptions, mostly in the earliest cases where the second and third intercostals were not divided within the intervertebral foramina and where sympathetic denervation was incomplete from the start, the early excellent results have been maintained.

Other authorities who have commented on the importance of limiting resection to the preganglionic sympathetic fibers, in order to avoid the extreme sensitization of the denervated vascular wall to adrenaline and sympathin, include Telford²⁵ and Learmonth.²⁶ Up to date, however, the follow-up statistics of the new methods which have been advocated to carry out a preganglionic denervation of the upper extremity have been too meager to evaluate their ultimate effectiveness.

Thromboangiitis Obliterans.—Learmonth,²⁶ in reviewing a series of cases with this disease, has classified them in certain groups:

"1. An early group, usually (and wrongly) labelled Raynaud's disease in the male.

"2. A group in which the disease is very slowly progressive, so slowly that it may appear to reach a certain stage, after which it does not progress. Thus cases are not rare in which claudication has been the only symptom for many (e.g., fifteen) years.

"3. A group in which the progress is episodic, the episodes corresponding to waves of thrombosis.

"4. A group in which the disease progresses rapidly to massive gangrene."

It is in Groups 1 and 2 that sympathectomy is indicated in the presence of a suitable vasodilator response to heating or novocain block. The operation "may obviate or at worst delay amputation; or it may allow a below-knee rather than an above-knee amputation." Both Learmonth²⁶ and Telford¹² have come to the conclusion that "when the disease affects the lower extremities it is unwise to consider the problem as unilateral, the so-called sound leg often being 'sound' only because it has been spared by the earlier appearance of claudication in the other." Therefore, operation should usually be bilateral.

Gask and Ross,²¹ in the second edition of their textbook, state that after sympathetic ganglionectomy:

While experimental evidence has offered little hope of surgical success in the attempt to reduce essential hypertension, operative results in human beings have been distinctly more encouraging. The unsatisfactory results of medical treatment and the high mortality of the disease make any surgical attempt at relief justifiable, provided it carries a low risk. Experimental animals cannot be submitted to the cortical emotional drive (see above) to which the pressor centers in the human hypothalamus are exposed, and it is well known that patients with essential hypertension exhibit an abnormal pressor response to such stimuli as emotional excitement or sudden exposure to cold. Allen and Adson⁵² have shown that these rises in blood pressure may be greatly reduced in patients after sympathectomy. These authors report a series of 85 patients treated by splanchnic and lumbar sympathectomy at the Mayo Clinic. Fifty-five per cent responded by a good fall in blood pressure (an excellent reduction to practically normal values in 25 per cent), while about 70 per cent showed favorable subjective and clinical improvement. There were no operative deaths in the entire series. The operation itself does not disable, although anhydrosis of the lower extremities and loss of ejaculation and probably of fertility in the male result. In the favorable cases the heart may decrease in size, inverted T-waves in the electrocardiogram may become upright, retinitis and spasm of the retinal arteries may diminish or disappear, albuminuria may decrease and renal function improve. But even after the most careful possible selection of cases, blood pressure was not materially reduced in 45 per cent.

Freyberg and Peet⁵³ have discussed the effects of bilateral splanchnicectomy in patients with essential hypertension. In general they have observed that changes in the kidneys are associated with changes in blood pressure. In those patients who had a significant and maintained fall, urinary abnormalities decreased or disappeared. Their observations indicate that in primary hypertension renal efficiency is not dependent on the higher blood pressure, as has been commonly thought since Traube, in 1856, first postulated the Compensatory Theory of the cause of the elevated blood pressure. The authors believe that the impairment of renal function is caused by vascular constriction and that if the constriction is relieved by splanchnicectomy the activity of the kidneys is improved.

Page and Heuer⁵⁴ have studied the cardiovascular and renal changes in 9 patients after thoracic splanchnicectomy and interruption of the thoracic sympathetic chain. Three of these suffered from the malignant form of the disease and cannot fairly be included. In the others they were unable to detect any improvement in cardiac or renal efficiency. The reduction in arterial pressure was marked, but within six months it had returned to the preoperative level in all patients. In the 6

ing blood of a patient during such crises by perfusing a sample of plasma through the denervated arteries of a rabbit's ear. This caused constriction of the sensitized vessels. The pressor effect disappeared after removal of the tumor and was not present on perfusion with normal plasma. Another variety of hypertension due to an abnormality of the endocrine glands is seen in the basophile adenomas of the pituitary. No satisfactory surgical solution has been advanced for this condition. The same applies to hypertension in cardiovascular and renal disease, with the rare exception of nephrectomy when a single kidney is diseased.

The treatment of essential hypertension by various operative procedures represents the newest extension of surgery in therapy. This subject is at present in a state of evolution and it is highly important to follow the work of both the experimenter and the clinician. Very little encouragement has been given the surgeon from the laboratory. It is known that blood volume and viscosity, as well as cardiac output, are normal in this disease. The resistance to flow of blood through the arterioles is increased, but the question remains whether the reason for this is due to increased vasoconstrictor tone or to an abnormal pressor substance circulating in the blood. Page⁴⁷ reports that as yet there is no direct evidence of any pressor substance in the blood, urine, or spinal fluid. Nonetheless, it has been proved conclusively that hypertension in the Goldblatt dog with partial compression of the renal arteries is not neurogenic. Freeman and Page⁴⁸ have been unable to produce any fall of blood pressure in these animals after complete sympathectomy and cardiac denervation. Furthermore, hypertension has been produced by Glenn, Child, and Heuer,⁴⁹ as well as by Blalock and Levy⁵⁰ through constriction of the artery of a single transplanted kidney devoid of a nerve supply. The only procedure which has been found to reduce this type of hypertension is bilateral adrenalectomy.⁴⁷ This effect is not due to lack of medulliadrenal secretion, but to the cortex, and fits in with the hypothesis of Page⁴⁷ that cortical secretion is concerned with the maintenance of the vascular system in a state of reactivity. When this secretion is lacking, it is possible that the vessels can no longer respond to chemical pressor stimuli. Although no abnormal pressor substances have been demonstrated in the blood of these animals, physiologic evidence points indubitably to their presence. If the mechanism of essential hypertension is due to a fault in the blood supply of the kidney, it is possible that this may be improved by sympathectomy.

A true neurogenic form of hypertension has been produced in dogs by Heymans and Bouckaert⁵¹ by resecting the carotid sinus and cardio-aortic depressor nerves. In such an animal normal blood pressure can be restored by total sympathectomy, but no lasting reduction results from resecting the splanchnic nerves and the lumbar sympathetic chains.

resection of the lumbar chains, as advocated by Judd and Adson, has been found to be still more effective. The operation of Rankin and Learmonth, which consists of the removal of the inferior mesenteric and superior hypogastric plexuses, has failed to give satisfactory results in the more advanced cases of Hirschsprung's disease. None of these operations are effective in relieving symptoms when the ascending and right half of the transverse colon are involved, nor in the atonic dilatation which accompanies the acquired form of the disease. For these conditions Adson has been resecting the splanchnic nerves together with the first and second lumbar ganglia bilaterally through posterior incisions carried out in two stages. This operation, which interrupts the sympathetic inhibitor fibers to the small intestine and ileocecal valve as well as the supply to the colon, promises to give far more effective results and should be given a wide trial. It must be remembered, however, that it will produce sterility in the male through a loss of the power of ejaculation. The same objection applies to operations which interfere with the nerves descending along the aorta and the superior hypogastric plexus.

SYMPATHECTOMY FOR VISCERAL PAIN

Learmonth²⁶ has summarized current anatomic knowledge of the viscerosensory nerves as follows: "Pain fibers from the viscera have the same morphological arrangement as somatic afferent fibers; that is, they are the axons of cells in the posterior root ganglia. Some of these fibers utilize sympathetic pathways to reach the spinal cord. They leave a viscus by its individual nerve-strands, usually traverse peripheral sympathetic ganglia, and the majority reach the paravertebral sympathetic chains by way of the pelvic splanchnic nerves (pelvic viscera), thoracic splanchnic nerves (abdominal viscera), and cervical splanchnic nerves (thoracic viscera). After entering the paravertebral chains they may run cranially (or caudally) for varying distances; finally they traverse white rami communicantes, and thence pass by way of the posterior root ganglia and the posterior nerve-roots to the spinal cord. . . . Although the mechanism of production of visceral pain cannot be regarded as finally settled, the majority of observers are agreed that it arises as the result of tension in the viscus, whether this is the result of distension, of inability to evacuate its contents, or of inco-ordinated muscular contraction."

While distention seems to be the principal cause of pain in colic of the hollow viscera, another mechanism must account for arterial pain. Moore and Greenberg²⁷ have studied the mechanism of pain in coronary occlusion. Having previously found that lactic acid causes striking pain responses when injected into a coronary artery, they determined the acidity of the blood obtained from the veins of the functioning heart

patients with the more benign form of the disease, the reduction of headaches, fatigability, nervousness, and irritability was striking, although in 3 improvement lasted less than a year; in the 3 with malignant hypertension it was but transient. The therapeutic results in this small but representative group of patients are certainly not encouraging.

The results of the same operation in the hands of Peet at Ann Arbor and Smithwick³⁰ at the Massachusetts General Hospital have been very similar to those after the subdiaphragmatic resection of the splanchnic nerves and upper lumbar ganglia at the Mayo Clinic. But in spite of these more favorable reports, it has not yet been established that the expected duration of life in hypertensive patients can be prolonged, even if the blood pressure is reduced. More accurate methods for selecting cases favorable for sympathectomy and longer observation of patients who have been subjected to this procedure are the two most important points required to place the surgical treatment of essential hypertension on a sound basis.

VISCEROMOTOR CONTROL OF AUTONOMIC NERVOUS SYSTEM

Megacolon.—The term Hirschsprung's disease signifies a congenital dilatation of the colon of neurogenic origin and serves to distinguish this condition from the acquired form which is caused by chronic obstruction or by faulty habits of defecation. Experience with improvements in the technique of denervation suggests that neurosurgical methods may entirely supplant the old and dangerous procedure of colectomy in cases where there is no mechanical obstruction. The act of defecation is accomplished by parasympathetic nerve impulses which arise from the sacral segments of the spinal cord as stretch reflexes. They increase the tone of the detrusor muscle and relax the internal sphincter. In opposition to the sacral autonomic fibers, the sympathetic outflow from the lowest thoracic and upper lumbar segments of the spinal cord causes inhibition of detrusor activity and a tightening of the involuntary sphincters. In a recent monograph Passler⁵⁵ has assembled information concerning the origin and treatment of megacolon from many angles.

Adson⁵⁶ reviews the various forms of sympathectomy which have been advocated. He argues that surgical intervention should depend on an evaluation of the degree of the disease and emphasizes the importance of selecting a method of denervation that will include sufficient sympathetic inhibitor fibers to re-establish a balance of the neuromuscular mechanism. In the milder group of cases, where the disease is limited to the lower portion of the descending colon, left lumbar ganglionectomy (the operation of Wade and Royle) alone is usually sufficient. Bilateral

⁵⁵This monograph has been highly recommended in the reviews of new books, but it has been impossible to obtain a copy from any library to date.

eases treated in this way. This operation will effect a cure of rebellious cases of idiopathic dysmenorrhea which have been refractory to all other forms of therapy. Cotte feels that in certain cases reported in the literature failure has been due either to incomplete resection or to the fact that the patients were poorly selected for operation. The operation will not relieve ovarian pain, which travels in the plexuses along the ovarian vessels. There have been no abdominal complications or difficulty with the sphincters. More than 50 patients have had consecutive pregnancies without accident.

CONCLUSIONS

During the course of the eight years in which these reviews of advances in sympathetic neurosurgery have been written, there has been a noticeable restriction of its applications. Its use in epilepsy, for which the first sympathetomy was done, has long since been discarded. So has the attempt to reduce spasticity, undertaken by Hunter and Royle, as a by-product of which the modern operations for Raynaud's disease and megacolon have developed. Sympathectomy has been found to be of little or no value in various conditions for which it has been enthusiastically advocated, such as bronchial asthma, retinitis pigmentosa, atypical forms of facial neuralgia, and in the relief of joint symptoms in rheumatoid arthritis.

On the other hand, a great deal has been learned in the last few years about the integration and control of the involuntary nervous system by the higher centers in the cortex and hypothalamus, and also through such peripheral sensitive areas as the carotid sinus. Likewise knowledge of the anatomic arrangement of the visceral plexuses has become much more exact and has explained the cause of failure in the older operations for angina pectoris and megacolon. A more complete understanding of the physiologic behavior of denervated smooth muscle is leading to better handling of the problems connected with peripheral vascular disease. Interest is now focused on the surgical treatment of essential hypertension, where the value of sympathetomy must still be regarded as *sub judice*. With the exception of this condition, clinical experience has now led to a fairly exact appreciation of what sympathetic neurosurgery has to offer towards the correction of abnormal visceral function and the relief of visceral pain.

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at varying intervals after ligation of both coronary arteries. The coronary venous blood showed a marked lowering of pH and the lactic acid content was greatly increased. In three animals the pH fell below 6.6 and in one it reached 6.4. Definite pain responses can be elicited by intra-arterial injections as weakly acid as pH 6.3, and it is certain that there would be a greater concentration of acid metabolites in the capillaries and tissue spaces of the laboring muscle in actual coronary infarction than could have been detected in the blood of the coronary sinus during the brief period of these experiments. This is clear-cut evidence that the pain of coronary disease is due to an irritation of the sensory nerve endings in the heart by acid metabolites, just as is the case with skeletal muscle during periods of intermittent claudication.

Interesting observations have been made by Leriche⁵⁹ on pain produced by direct stimulation of the central end of the splanchnic nerve in two patients undergoing splanchnicectomy under spinal anesthesia. Each complained of severe pain in the chest; in one instance it was referred to the heart, in the other to the lung on the ipsilateral side.

Ochsner and De Bakey,⁵⁹ in their review of the surgical treatment of coronary disease, give statistics on the results of the various methods of cardiosensory denervation. Excellent anatomic diagrams are included to show the arrangement of the cardiac nerves and the importance of interrupting the direct thoracic as well as the cervical fibers. Their statistics show that when cervicothoracic sympathectomy was used there was rather a large number of failures because these operations fail to interrupt the accessory afferent fibers in the direct thoracic rami. As the authors state: "The ideal procedure should be resection of the upper four or five thoracic sympathetic ganglia. In this way all fibers carrying sensory impulses from the heart would be interrupted. However, such a procedure in patients who are admittedly poor risks would undoubtedly carry an unjustifiably high mortality."* In the statistics compiled by Ochsner and De Bakey, about 80 per cent of the 68 patients subjected to paravertebral alcohol injection were relieved of severe anginal attacks which had not responded to medical treatment, with a mortality rate of 1.5 per cent. A certain number of failures are unavoidable, due to the technical difficulty of blocking all of the cardiac rami in thick-chested individuals. Under these circumstances recourse may be had to posterior root section with an almost certain expectation of success, provided the patient is in sufficiently good condition to be subjected to so radical a procedure.

Another successful application of sympathectomy of pain of visceral origin is seen in presacral neurectomy in obstinate cases of dysmenorrhea. Cotte,⁶⁰ the originator of this operation, reports a series of 300

*In my own series of four patients where the upper three thoracic ganglia had been resected, relief was complete except for slight residual arm pain in one instance. In four unpublished cases of other surgeons where the upper five thoracic posterior spinal roots have been cut, the pain has been consistently relieved.

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the procedure and stressed the limitation of the operation. The details of the second procedure as originally described in 1932 have remained practically unchanged. The first stage consists of a preliminary stretching of the soft tissues about the hip continued until the head is pulled down opposite the site of the original acetabulum. In the author's hands this has been most satisfactorily accomplished by using skin or skeletal traction while immobilizing the opposite hip in a plaster spica. In the older cases a previous subperiosteal stripping of the gluteal muscles about the crest of the ilium unquestionably has helped in obtaining soft tissue relaxation.

The second stage consists in preserving the hour-glass portion of the capsule covering the head. The redundant capsule about the old acetabulum has been removed and a new acetabulum made with a large curette after which the capsule covered head is placed deeply within the reconstructed acetabulum and the wound closed in layers. After four weeks the plaster spica has been completely removed and active and passive motion started in an overhead swinging apparatus. No weight bearing is allowed for three months following the second stage.

Colonna stresses the fact that the most satisfactory results have been obtained in the unilateral case under 10 years of age and he described the procedure in a movie film showing a number of patients presenting a normal range of hip motion.

Frank R. Ober, Boston, Mass., read a paper on Discoid Cartilage and Trigger Knee, Pathology and Treatment. He reported three cases which were diagnosed at the Boston Children's Hospital and one adult private case of the writer's. The treatment for such disability, according to Ober, is that the cartilage must be removed; if this is not done, the mechanical irritation of the cartilage, which is becoming enlarged from the cyst formation, is likely to injure the articular surfaces and produce arthritic changes.

Philip Wilson, New York, N. Y., read a paper entitled Popliteal Cyst (Baker's Cyst), Its Etiology, Pathology, and Treatment. He stated that in the majority of cases he found a composite bursa present, consisting of the so-called gastrocnemius and the semimembranosus bursae. This lay under the inner head of the gastrocnemius muscle and under the semi-membranosus tendon, extending posteriorly between these two muscles and finally lying quite superficially under the deep popliteal fascia. The author's conclusion was that popliteal cysts are in the great majority of instances inflammations of the gastrocnemiosemimembranosus bursa and probably the result of traumatic irritation of the cursal sac. The treatment recommended is complete surgical removal.

An afternoon Clinic on Tuesday, May 3, was given over to a Symposium on bone tumors, made up of James Ewing, New York, N. Y.; Robert D. Schrock, Omaha, Neb.; Bradley L. Coley, New York, N. Y.; and Henry W. Meyerding, Rochester, Minn. Dr. Coley discussed Giant Cell Tumor of the Bone.

Giant Cell Tumor of Bone, by Bradley L. Coley and Norman L. Higinbotham, New York, N. Y. After an historical survey, Coley and Higinbotham reported on a series of 124 cases of giant cell tumor of bone from their services at the Memorial Hospital and the Hospital for Ruptured and Crippled. The average age at the onset of the disease was 29.7 years; 45 per cent of the patients were females and 55 per cent were males. As to the bone involved, the distal end of the femur, the proximal end of the tibia, and the distal end of the radius, accounted for 75 of the 124 cases. In the differential diagnosis there were many bone lesions that had to be distinguished from the giant cell tumor, among them:

Review of Recent Meetings

FIFTY-SECOND ANNUAL MEETING OF THE AMERICAN ORTHOPAEDIC ASSOCIATION, MAY 2-4, 1938

H. EARLE CONWELL, M.D., BIRMINGHAM, ALA.

THE FIFTY-SECOND Annual Meeting of the American Orthopaedic Association was held at the Ambassador Hotel, Atlantic City, New Jersey, on May 2, 3, and 4, 1938, under the presidency of Frederick C. Kidner, Detroit, Mich. This meeting was held in conjunction with the Fiftieth Congress of American Physicians and Surgeons, since the American Orthopaedic Association is one of the component organizations.

J. A. Freiberg, Cincinnati, Ohio, spoke on the scalenus anticus muscle and its relation to shoulder and arm pain. He stated that spasm or contracture of the scalenus anticus muscle may cause pressure on the subclavian artery and brachial roots and may produce combined vascular and nervous symptoms. He enumerated many common lesions of the shoulder girdle and cervical spine, such as calcification of the supraspinatus tendon, arthritis of the shoulder or the cervical spine, and others which are frequently complicated by spasm of the scalenus anticus muscle. He stated that brachial neuritis is usually a sign of the scalenus anticus muscle and that brachial neuritis is usually a sign of scalene spasm or contracture, rather than a true clinical entity. Concerning treatment, the author felt that two factors must be considered, the etiologic factor, or primary lesion, and the degree of vascular and neurologic changes which have occurred. Briefly, Freiberg believes that the initial therapy should be directed to the lesion which is causing the scalene spasm. Combined with this therapy some form of simple balanced traction applied to the arm has relieved the symptoms in several cases. Postural variants, such as the long neck, flat chest type, predispose to the scalene syndrome. Therefore, in some cases postural therapy is indicated. If the symptoms are severe and associated with vascular or neurological or combined changes, tenotomy of the anterior scalenus muscle should be done as advocated by Ochsner.

Eugene B. Mumford, Indianapolis, Ind., read a paper entitled Osteoporosis. He did not discuss the theories of osteoporosis, but reported a series of cases treated by x-ray therapy. The treatment consisted of daily doses of 150 to 175 x-ray hours to the affected part for four days. This light dosage, according to Mumford, did not in any case produce any evidence of skin irritation. The dosage could be repeated at the end of three or four weeks.

Paul C. Colonna, Oklahoma City, Okla., presented a paper entitled An Arthroplastic Procedure for Congenital Dislocation in Children. Colonna stated that an arthroplastic procedure for congenital dislocation of the hip has been emphasized by him for the past eight years, and this presentation reviewed the technique of

the procedure and stressed the limitation of the operation. The details of the second procedure as originally described in 1932 have remained practically unchanged. The first stage consists of a preliminary stretching of the soft tissues about the hip continued until the head is pulled down opposite the site of the original acetabulum. In the author's hands this has been most satisfactorily accomplished by using skin or skeletal traction while immobilizing the opposite hip in a plaster spica. In the older cases a previous subperiosteal stripping of the gluteal muscles about the crest of the ilium unquestionably has helped in obtaining soft tissue relaxation.

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simple bone cyst, von Recklinghausen's disease, central chondroma or chondromyxoma, medullary osteolytic osteogenic sarcoma, and, rarely, plasma-cell myeloma.

Coley and Higinbotham recognized the two conservative methods of treating the giant cell tumor; namely, surgical extirpation by curettage or resection, and radiation by radium pack or roentgen ray. They reserved radical surgery, i.e., amputation, for frankly malignant cases or for exceptional ones in which the tumor was situated in the lower end of the extremity where an artificial limb assured a proper functional result. They did not feel that the question was finally settled as to whether radiation or surgery was the better method, and the wide divergence of opinion would seem to indicate that neither extreme view was correct. Their experience had led them to adopt surgery for lesions that were accessible, particularly those that were in the region of the knee joint, and radiation for lesions that were inaccessible, particularly those in the spine, pelvis, or neck of the femur. They warned against the use of radiation and surgery in the same case.

The technique of treatment by surgery and by radiation is separately described. In closing they presented tables listing the results of treatment, as follows:

TABLE OF RESULTS OF TREATMENT OF 124 CASES OF GIANT CELL TUMOR

| TREATMENT | CASES | EXCELLENT RESULT | GOOD RESULT | POOR RESULT | UNCLASSIFIED |
|-------------------------------------|-------|---------------------|----------------|----------------|--------------|
| Surgery alone | 35 | 17 or 57% | 6 or 20% | 7 or 23% | 5 |
| Radiation alone | 53 | 14 or 34% | 12 or 30% | 15 or 36% | 12 |
| Combined (surgery and radiation) | 34 | 7 or 22% | 8 or 25% | 17 or 53% | 2 |
| Coley's toxins alone | 2 | 1 or 50% | 1 or 50% | | |

| | | TYPE OF PREVIOUS TREATMENT | | |
|-------------------------------|--------------------------------|----------------------------|-----------|----------|
| | | SURGERY | RADIATION | COMBINED |
| Amputations, 26 cases: | For infection | 2 | 0 | 2 |
| Primary amputation 2 cases | For radiation changes | 0 | 4 | 2 |
| Secondary amputation 24 cases | For malignant transformation | 1 | 0 | 6 |
| | For failure to control disease | 2 | 3 | 2 |
| Total | | 5 | 7 | 12 |
| Percentage of followed cases | | 17% | 17% | 37% |

SUMMARY OF RESULTS OF TREATMENT IN 124 CASES OF GIANT CELL TUMOR AT MEMORIAL HOSPITAL AND HOSPITAL FOR RUPTURED AND CRIPPLED

| | CASES |
|------------------------------|-------|
| Alive and under observation | 83 |
| Lost to follow-up | 19 |
| Dead: | 22 |
| Causes related to bone tumor | 14 |
| Causes unrelated | 4 |
| Cause unknown | 4 |
| Total | 124 |

The conclusions reached by Coley and Higinbotham were: (1) The giant cell tumor is usually benign but malignant forms are encountered and may result from the transformation of a tumor that is histologically benign at the outset.

(2) Surgical extirpation (eurettage, resection, and, on rare occasions, amputation) and radiation have been established as successful methods of treatment. Surgery is preferable for accessible tumors, and radiation for inaccessible or extremely advanced tumors. (3) Caution should be exercised when using roentgen ray without histologic confirmation of the diagnosis, for one may be dealing with an osteolytic sarcoma which bears a close resemblance, roentgenographically, to the giant cell tumor. (4) Radiation should not be used in conjunction with surgery. Each method should bear the full responsibility of its employment in the individual case. (5) Roentgen ray in large doses destroys the regenerative powers of the bone; in small doses it may fail to arrest the disease; therefore, the exact dosage for the individual case is a matter of profound judgment or of fortuitous circumstance. (6) Inexpert radiation is probably less hazardous than surgery in the hands of one unfamiliar with technical operative details. Loss of limb may ultimately result in either instance. (7) Surgical attack should envisage thorough removal of all tumor tissue through adequate exposure, careful wound closure without packing or drainage, and primary wound healing. (8) Protection during the regenerative phase is essential regardless of the treatment employed, for a pathologic fracture usually spells functional impairment and a painful neighboring joint.

Gilbert E. Haggart, Boston, Mass., discussed **True Idiopathic Sciatica** wherein he presented the method of treatment for sciatic pain of unknown origin. He used a method of three procedures in some, a combination of two, but in most instances three: (1) Perineural injection of the sciatic nerve with novocain (1 per cent); (2) traction to the affected extremity; and (3) in an increasing number of cases, manipulation of the low back under intravenous pentothal anesthesia. After carrying out these procedures all patients are instructed in muscle exercises, particularly designed to develop the low back muscles and those of the gluteal group. On becoming ambulatory, posture training is also given as indicated.

Frank N. Potts, Buffalo, N. Y., discussed **Aseptic Necrosis of the Head of the Femur, Following Traumatic Dislocation**. He reported five cases of aseptic necrosis of the head of the femur following traumatic dislocation. In none of these cases were fractures present. The dislocations were reduced in four cases within forty-eight hours and in the one case, within two weeks; no great difficulty was encountered in reduction. Four of the five cases were the result of automobile accidents. There was a long period of well-being, followed by pain, limp, and restricted motion in the affected hip. Radiographic examination showed what Potts believed to be an aseptic necrosis, with a resultant arthritis in the hip. Microscopic study of sections of bone removed showed a thinning of the articular cartilage and break down in the subchondral bone, allowing for the altered shape of the hip joint; there was some attempt to repair by invasion.

These patients, stated Potts, were seriously disabled with a progressively destructive lesion, involving the head of the femur. The diagnosis was readily made on suspicion and with the x-ray findings. With knowledge of this condition, it becomes increasingly difficult to offer a good prognosis in the dislocated hip. While statistics are rather scarce, it would seem from inquiry that this might not be an unusual condition. If the diagnosis was made early enough it is possible that keeping the person from bearing weight might have a beneficial effect, in that it would lessen the chance for alteration in the shape of the head of the femur. It might also be considered that drilling through the head and the neck might bring about some improved blood supply. Undoubtedly, the original pathology is a destruction of the capital blood supply as it goes through the capsular vessels

and ligamentum teres. The treatment rests between an arthroplasty and an arthrodesis; Potts favors the latter procedure. The choice would depend upon the amount of destruction of the head.

Arthur Steindler, Iowa City, Ia., discussed Nonparalytic Scoliosis, Principles of Treatment and Nonoperative Management. Steindler stated that first, it is shown that the compensation, that is the realignment of the body over the trunk, is a necessary prerequisite for the success of both conservative and operative treatment. This is documented by long range observation and the statistical curves of these observations show definitely that cases which had an adequate compensatory treatment before fusion, held after the fusion was done, whereas cases in which compensation treatment was not carried out, or could not be carried out to a satisfactory degree, did not hold, but they relapsed after a short initial period of apparent success. The statistical curve of those cases that were secured by conservative treatment and in which adequate compensation was accomplished prior to fusion, did hold during periods of long range observations where the others did not. It appeared, however, from Steindler's observations, that too many cases were selected for conservative treatment. All in the late end results showed by the permanency of the correction that only about 40 per cent of the cases that he saw were suitable to conservative treatment alone.

Steindler believes that the reason for the rather low percentage of long range successes in conservatively treated cases is due to the difficulties of correcting the curve itself, aside from the compensation realignment. Consequently, he goes a step farther in correction of the curve. Steindler believes from x-ray observations that the keynote to the correction of the curve is the derotation. This derotation of the curve is carried out with specially designed equipment, both in the sitting and lying positions. It is to be expected that a higher percentage of permanent control of scoliotic spines, both in the conservative and operative treatment, will result from this added feature of the correction of the curve itself. The correction of the lateral curve is carried out both by active and passive exercises and by the corrective cast methods after Risser. Steindler's total material embraces 1,600 cases. Drs. W. R. Hamsa and Cooper, Iowa City, Ia., collaborated in this study.

The Presidential address, Progress of Orthopedic Surgery in America, was given by Frederick C. Kidner. T. P. McMurray, of Liverpool, who was the Association's guest, read a paper entitled Osteoarthritis of the Hip.

Book Reviews

Pediatric Surgery. By Edward C. Brenner. Cloth. Pp. 843, with 203 illustrations. Philadelphia, 1938, Lea and Febiger. \$10.

With the exception of fractures, all of the surgical specialties pertaining to pediatric surgery are included in this volume. Six topics or specialties, including anesthesia, blood transfusion, cleft lip and palate, thoracic surgery, genito-urinary surgery, and neurosurgery, are very ably contributed by colleagues of the author. The purpose of the book is described in the preface as being of a practical nature and not encyclopedic or compendial in type. Apparently, for that reason the author has entirely omitted a bibliography. To many readers this feature will be considered unfortunate. In the author's endeavor to be concise and practical he resorts to an attitude of dogmatism in numerous sections which would be properly tempered by a generous number of references.

The endeavor to include a bounteous supply of clinical facts has been very efficiently executed. On numerous occasions statements are made which would not meet with complete approval by many surgeons. For example, certainly not all surgeons are as thoroughly convinced of the value of intraspinal tetanus antitoxin as the author is.

From the clinical standpoint, embryological and anatomical data have been very adequately covered. The short introduction outlining the various features in which children differ from adults is very useful and appropriate. Congenital malformations which make up such an important part of pediatric surgery are considered in various parts of the book. Congenital malformations of the rectum are very thoroughly and efficiently described, but the anomalies of the small intestine, which are of so much importance from the standpoint of the infant's life because of the frequency of obstruction, particularly at the duodenum and terminal ileum, are mentioned only very briefly. Other inconsistencies in the amount of space devoted to various subjects are apparent. For example, acute cervical lymphadenitis is such a frequent and serious disease in children that more than one and one-half pages would appear to have been appropriate.

In the preface the author states that he wishes to avoid mentioning procedures, etc., which are of doubtful value. The use of Hartmann's combined solution is not discussed. There are undoubtedly many pediatricians and surgeons who believe this to be a very useful and efficient agent, and to be an effective buffer, particularly in acidosis. In the section on shock, gum acacia is not mentioned as a substitute for plasma when blood is not immediately available. Many surgeons would probably consider gum acacia to be past the experimental stage and of definite therapeutic value.

Certain sections of the book are especially well written and contain a thorough, concise discussion of all the informative data desired. This may be said particularly of the section on acute osteomyelitis, thoracic surgery, and genitourinary surgery.

The reviewer hoped to find a more thorough discussion of postoperative feeding, particularly in such conditions as pyloric stenosis where serious vomiting may ensue as the result of improper or too large feedings, and be corrected so promptly by

changing the feeding or lessening the quantity for 24 to 48 hours. The postoperative administration of fluids, etc., is discussed rather briefly, but the author obviously relies very strongly on the pediatrician to take care of these phases of therapy.

As stated previously, the book contains an enormous amount of practical data so useful and necessary in the surgical care of infants and children. For that reason, it will be a very valuable addition to the library of the pediatric surgeon.

Quelques Vérités Premières (ou soi-disant telles) en Chirurgie Abdominale. By H. Mondor. Pp. 96. Paris, 1937, Masson & Cie. 24 fr.

In 1881 or thereabouts the late Mr. E. Hurry Fenwick, Surgeon to and Lecturer on Clinical Surgery at the London Hospital, gathered together a number of accepted precepts from well-known standard treatises of surgery for the use of his dressers and senior students, to supplement the theoretical knowledge which they had acquired. This compilation proved so popular that it was printed under the title of *Golden Rules of Surgical Practice* and ran through six editions, with additions and changes from Mr. Fenwick's own pen. In 1906 a new book, entitled *Golden Rules of Surgery*, based on the foregoing but with many additions from the rich fund of his own personal experience, was issued by the late A. C. Bernays, of St. Louis, including his original observations on such matters as fees, professional methods, scientific contributions, and economic questions of interest to surgeons.

The volume now under consideration (*Some Fundamental Truths in Abdominal Surgery*) is constructed much on the same plan, except that it is confined solely to the scientific aspect and makes no note of collateral issues. It is one of ten volumes, all made up of paragraphic aphorisms; each volume is by a different writer, under the general editorship of L. Ombrédanne and N. Fiessinger, who state in their preface that while aware that much of the current knowledge of today ultimately will be discarded, there is much that is so definitely established that it can be accepted with finality. It is on this latter type of information that these books are made up, and they cover practically the entire field of modern surgery. All of the authors are members of the Faculty of Medicine of Paris; in the present instance the author is Assistant Professor of Pathological Surgery, as well as Surgeon to the Hôpital Bichat.

He has assembled his material into three major groups. Group A covers the abdominal wall, the stomach, duodenum and pancreas, with subsections on contusions and wounds of the abdomen, traumatic rupture of the spleen, thoraco-abdominal wounds, fibroma of the abdominal wall, strangulated hernia, ulcer of the lesser curvature, ulcer of the duodenum, peptic ulcer of the stomach, cancer of the stomach, benign tumors of the stomach, hour-glass stomach, stenosis of the pylorus and duodenum, perforated ulcers, subphrenic abscess, acute phlegmonous gastritis, acute occlusion of the duodenum, pancreatic cyst, sarcoma of the pancreas, chronic pancreatitis, cancer of the pancreas and acute hemorrhagic pancreatitis. Group B deals with the intestines and peritoneum, giving consideration to acute intestinal obstruction, intussusception, strictures of the small intestine, gallstone obstruction, volvulus of the cecum and pelvic colon, gangrene of the intestine, disease of Meckel's diverticulum, mesenteric cysts, acute and chronic appendicitis, inflammatory tumors of the right iliac fossa, cancer of the cecum, iliocecal tuberculosis, acute peritonitides, typhoid perforations, streptococcus, pneumococcus, gonococcus, and tuberculous peritonitis, cancer of the colon, ulcerative colitis, polyadenoma of the

large intestine, anal fissure, peri-anal abscess and fistula, stricture of the rectum, and cancer of the rectum. The third section is given up to the major problems of gynecology, including tubal pregnancy, complicated abortions, the inflammatory, malignant, and benign conditions involving the uterus and adnexa, etc.

This somewhat extended review of the contents has been given to emphasize the scope and importance of this work. It is full of rich meat, beautifully—even dramatically—written but with the utmost economy of words. It deserves to be translated, for it would make a worthy addition to the literature of any language.

The Practice of Urology. By Leon Herman. Cloth. Pp. 923, with 504 illustrations. Philadelphia, 1938, W. B. Saunders Company. \$10.

The Practice of Urology by Leon Herman, Professor of Urology at the Pennsylvania Post-Graduate School of Medicine, is a very satisfactory textbook. It is logically arranged and presented, and admirably illustrated. Without knowing the author personally, the reviewer gets the impression that he is soundly conservative and open minded. Nevertheless, it is impossible for one urologist to review a book by another without discovering many differences of opinion.

The complete omission of discussions of operative technique (except for operative cystoscopy) should be mentioned, since the general practitioner at whom the book is avowedly aimed will need a text of operative surgery to accompany it. The omission was undoubtedly necessary to keep the book within one volume and is, on the whole, desirable.

Certain positive criticisms seem required. The legend that novocain is an effective topical anesthetic for the urethra ought to be destroyed. If it is, as the author says, "cruel to perform cystoscopy without analgesia," it is equally unfeeling to pretend that novocain, topically applied, produces any analgesia whatever.

Many will question Herman's statement that division of the isthmus of the horseshoe kidney is unsatisfactory; many more will properly deprecate his contention that only 15 per cent of hydronephroses due to obstruction at the ureteropelvic juncture are amenable to conservative surgery. Fifty per cent is more nearly correct.

The clinical picture of malignant renal neoplasms is rather inadequately presented in that its atypical clinical forms are insufficiently discussed.

All through the book the author exhibits a predilection for classifications so elaborate as to drive to despair any medical student who uses the book. This is especially striking in the case of "surgical inflammations of the kidney" (a poor term, incidentally, since it conveys the impression that the infections under discussion result from surgical operations), an outline classification of which occupies almost a whole page; nevertheless, the section is well done. Those who try to acidify infected urine with the recommended doses (15 to 60 gr. daily) of calcium or ammonium chloride are doomed to disappointment; it is doubtful whether methenamine is any longer regarded as "the most dependable drug." The newer antiseptics, including the ketogenic diet, are well discussed.

The section on the "neurogenic bladder" is entirely inadequate. Passing over the fact that the bladder cannot originate from the nervous system, an assumption certainly implied by the term, the discussion overlooks the recent literature and omits all reference to such important means of treating neurogenic vesical dysfunction as training, rest of the bladder, the use of pilocarpine to stimulate the detrusor, and the relief of complicating obstructions at the vesical neck. Measures for encouraging the development of an automatic bladder without catheterization in transverse myelitis are surely deserving of more emphasis. The author gives the im-

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pression, I think unintentionally, that its appearance is an accident; actually its development can be brought about deliberately without catheterization.

The chapter on cystitis fails, in an otherwise adequate presentation, to mention the most useful symptomatic treatment in interstitial cystitis—overdistention under anesthesia.

The section on obstruction at the vesical neck is excellent despite its advocacy of the now outworn gradual decompression of the distended bladder which is surely only of historical interest. The author takes a rational view of the indications for the various methods of relief without attempting to maintain the superiority of one method in all circumstances as so many writers now attempt to do. One may justifiably wonder what he means by "maturity" of prostatic hypertrophy, and criticize his use of the term "radical prostatectomy" for suprapubic or perineal enucleation of hypertrophies. Many will question his belief that transurethral resection is more dangerous than prostatectomy in larger prostates and in older patients. Emphasis ought to be given to the value of transfusion of blood in shock following operations upon the prostate. Otherwise the section on care after transurethral resection is very good.

In discussing cancer of the prostate Dr. Herman brings out the fact, overlooked in several recent papers which deprecate transurethral operations, that a cancer concealed within a hypertrophied lobe is not often cured by enucleation of that lobe; he points out that arguments for radical perineal prostatectomy lose much of their force when one considers how infrequently the operation is feasible (10 per cent or less of the cases of cancer).

Despite the minor criticisms cited, this is a sound and valuable book and is extraordinarily complete for a single volume. It has another advantage over many of the current single volume texts in that it contains a bibliography which, while brief, affords a satisfactory entrance into the literature for the reader of inquiring mind.

The International Medical Annual: A Year Book of Treatment and Practitioner's Index, Fifty-Sixth Year. Edited by H. Lettichy Tidy and A. Rendle Short. Cloth. Pp. 615, with 68 plates. Baltimore, Md., 1938, William Wood and Company. \$6.

This book is a review of the advances in the whole field of medicine during 1937. The pertinent literature in the various specialties is summarized in alphabetical order rather than by section. Among the reviewers of the surgical literature are Hamilton Bailey, Stanford Cade, A. Tudor Edwards, John Fraser, Ernest W. Hey Groves, C. Langton Hewer, J. P. Lockhart-Mummery, and A. Rendle Short.

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The printing and illustrations are excellent. The index is fairly comprehensive. In all, this is a well-written compilation and better than the average book of its kind.



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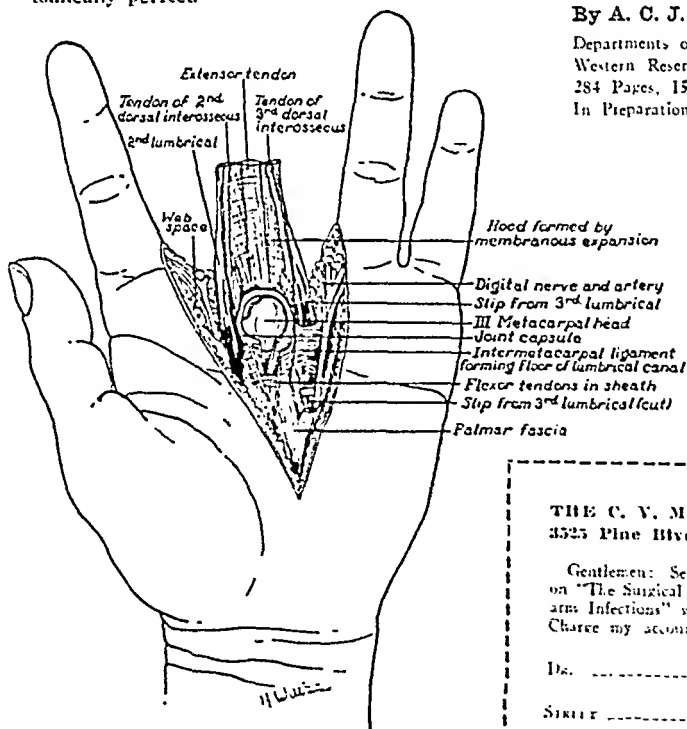
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SUMMARY OF CONTENTS

Chapter I—ANATOMICAL PLATES OF HAND AND FOREARM. These include the following with clinical notes: Palmar Fascia, Palmar Foyer, Cross Section Through Palm; Radial Bursa and Pronator Space; Ulnar Bursa and Pronator Space; Palmar Foyer and Ulnar Bursa; Deep Muscles and Ligaments; Web Spaces; Index Finger; Paronychia Region; Carpal Tunnel; Cross Section of Forearm; Dorsum of Hand; Cross Section Middle Joint Left Fourth Finger. Chapter II—RADIO-OPAQUE INJECTIONS OF THE HAND SPACES. Chapter III—GENERAL PRINCIPLES OF HAND AND FOREARM INFECTIONS. Anesthetics, Incisions, Physiotherapy. Chapter IV—REGIONAL SURGERY OF HAND AND FOREARM. This section is very detailed with the text matter well illustrated. Chapter V—BITES. Chapter VI—MEDICO-LEGAL ASPECTS OF HAND INJURIES.

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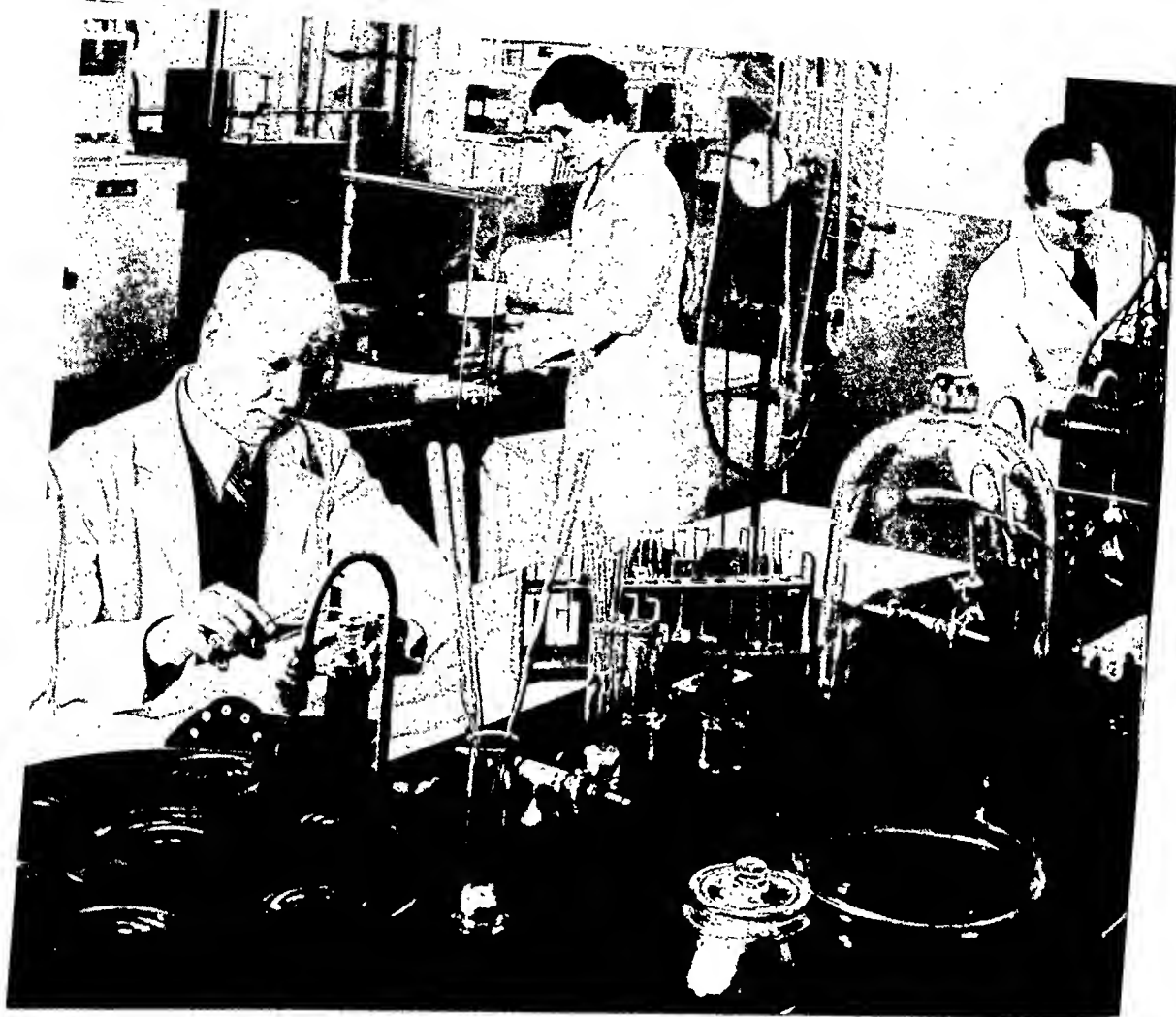
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*A Monthly Journal Devoted to the
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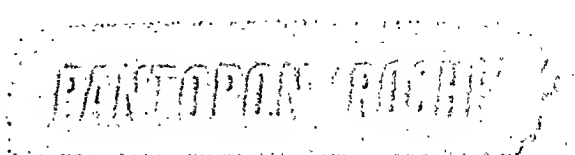


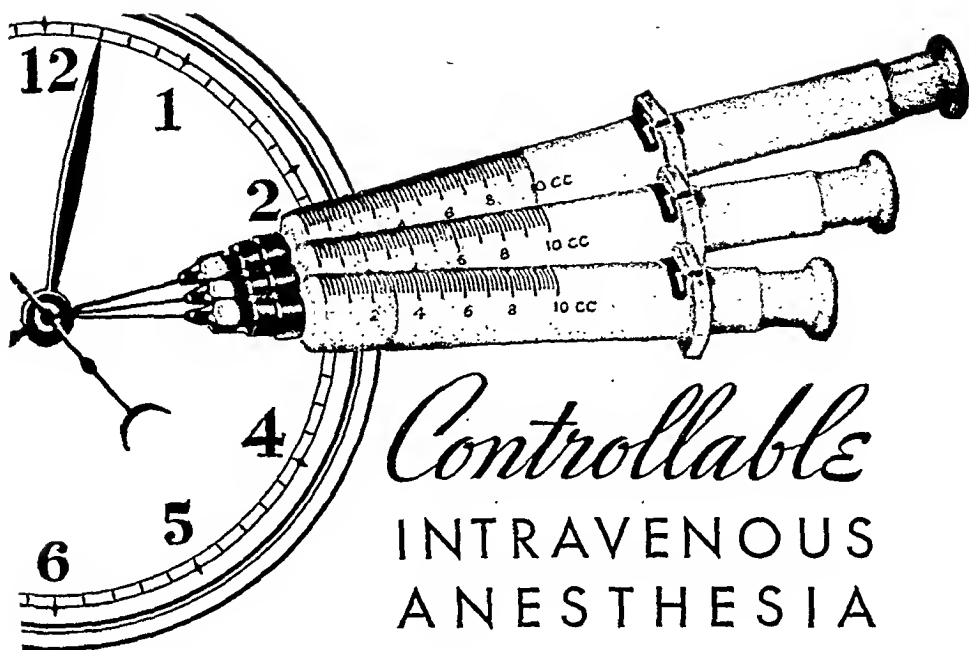
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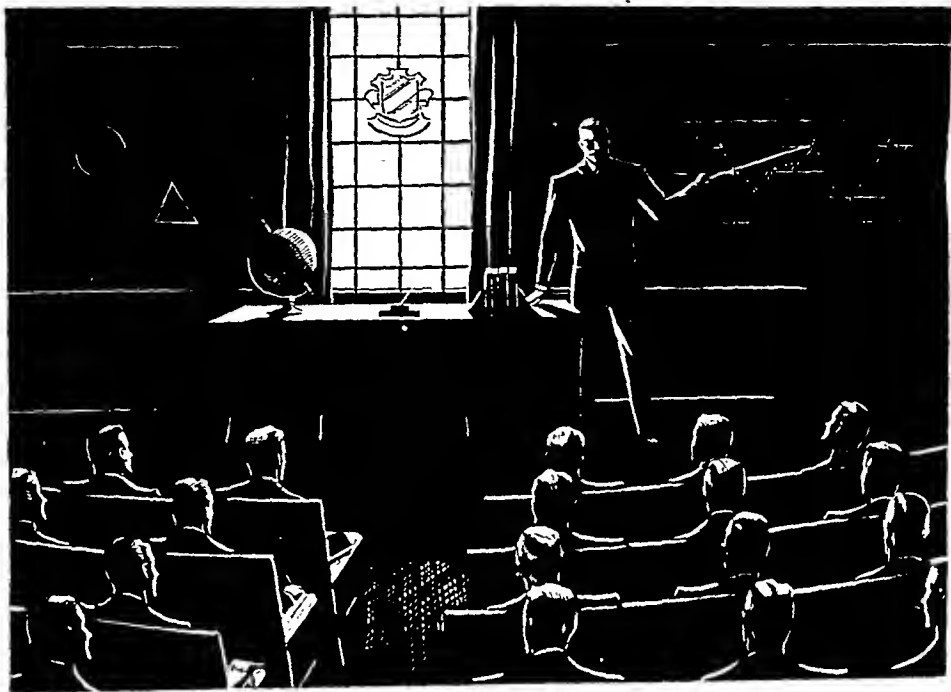
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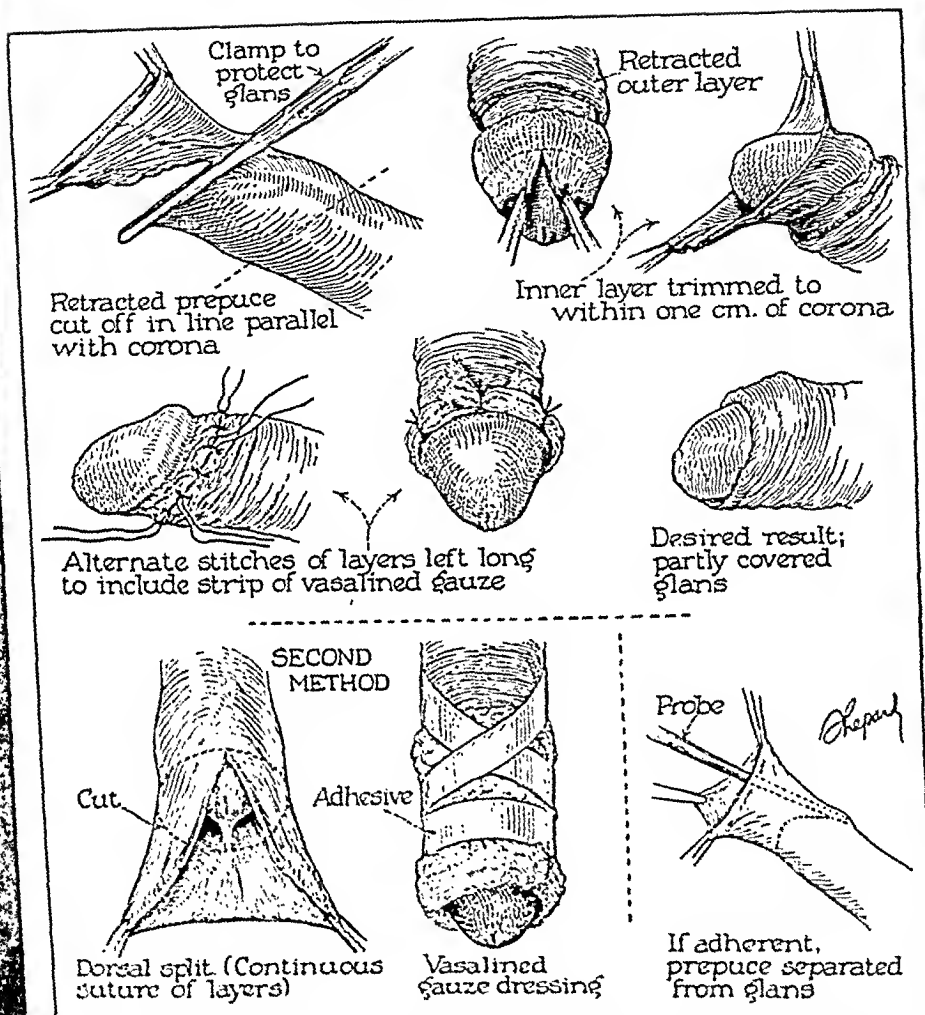
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Essentials of Obstetrical and Gynecological Pathology with Clinical Correlation

By MARION DOUGLASS, M.D., F.A.C.S., Assistant Professor of Gynecology, Western Reserve University; and ROBERT L. FAULKNER, M.D., Senior Clinical Instructor in Gynecology, Western Reserve University.

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From the Preface

FOR some years at the Western Reserve University we have found good pictures, properly grouped and displayed, of value in the teaching of obstetric and gynecologic pathology. Because of technical difficulties connected with repeated demonstrations of pictures, it occurred to us that they should be incorporated into a manual for easier use. Therefore, these pictures are brought together with a few paragraphs of text relative to the topics which they illustrate. The text includes, so far as possible, only those essentials which the student in an already crowded curriculum may be expected to grasp, or what the average clinical gynecologist or obstetrician may be expected easily to retain in mind.

The plan is to picture and discuss briefly from a clinical point of view the normal histology and common or important pathology of structures from the lower genital tract upward. This book is in no sense to be considered a complete atlas of pictures or the discussion exhaustive. In both pictures and text, we have followed fairly closely the elementary material presented each year in our students' course. In general, this is the common routine pathologic material as it is seen in the laboratory.

By keeping the text simple and the pictures those of normal histology and commonly seen pathology, we hope the manual may be particularly helpful to the student beginning his acquaintance with the special pathology of this field, and to the clinician who, for any reason, may want to review the essential histopathology of his specialty.

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No. 2

Original Communications

DELAYED OPERATION IN THE TREATMENT OF THE PERFORATED APPENDIX

CLARENCE E. GARDNER, JR., M.D., DURHAM, N. C.

(From the Department of Surgery, Duke University School of Medicine)

DELAY in operation upon a purely surgical intra-abdominal condition does not appeal, at first sight, to surgical instincts. Such practice in the care of the perforated appendix has never become universally popular in the forty-six years since it was first advocated by A. J. Ochsner¹ and at present it continues to represent one of the most controversial questions of surgical practice.²

We were trained in the belief that the only treatment for the perforated appendix was immediate operation, and such was our practice when the Duke Hospital opened in July, 1930. It soon became evident, however, that in some cases immediate operation did more harm than good. Convinced that the principles of delayed operation were surgically and physiologically sound, and encouraged by the statistics of those who had used this form of treatment, we gradually came to adopt the plan of delayed operation in all patients in whom a definite pre-operative diagnosis of perforated appendicitis could be made. This study records our experience with 248 cases of appendicitis with perforation admitted to the surgical service of the Duke Hospital from July, 1930, to July, 1937 (Table I).

The rationale of delaying operation in cases of appendiceal peritonitis is based upon the fact that a natural protecting mechanism exists within the abdomen which, if left undisturbed, is usually capable of causing the resolution or localization of appendiceal peritonitis. This protective mechanism consists of the inflammatory response to the presence of irritation within the peritoneum and is characterized by the outpouring of an exudate which is bactericidal and which contains leucocytes and fibrin. The fibrin agglutinates peritoneal surfaces of bowel, omentum, and abdominal wall in an effort to wall-off areas of inflammation from uncontaminated parts of the peritoneal cavity. This being possible, the

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TABLE I
GENERAL ANALYSIS OF ALL CASES STUDIED

| 1930-1937 | IMMEDIATE OPERATION | | DELAYED OPERATION* | | SUBSIDED NO OPERATION† | | TOTAL | |
|---------------------|---------------------|--------|--------------------|--------|------------------------|--------|-----------|--------|
| | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS |
| Acute appendicitis | 685 | 0 | 0 | 0 | 0 | 0 | 685 | 0 |
| Local peritonitis | 65 | 5 | 2 | 0 | 13 | 1 | 80 | 6 |
| Abscess | 75 | 7 | 10 | 3 | 50 | 2 | 135 | 12 |
| Diffuse peritonitis | 31 | 14 | 1 | 0 | 1 | 1 | 33 | 15 |
| Total | 856 | 26 | 13 | 3 | 64 | 4 | 933 | 33 |

*The conservative treatment was abandoned after an average period of 9 days because signs were not subsiding or were increasing.

†Symptoms and signs subsided completely or the patient died under conservative treatment without operation. Surviving patients discharged after an average hospitalization of 16 days to return for appendectomy in 3 months.

bactericidal effect of the inflammatory reaction is sufficient to cause complete resolution of the infection in the majority of properly managed cases. Such a protective mechanism is effective only if left undisturbed, disturbing elements being any factor, such as food or cathartics, which stimulates peristaltic activity in the bowel, or any mechanical procedure, such as operation, either of which may break up the protective barrier of agglutinated peritoneal surfaces and open the uncontaminated peritoneum to infection.

This concept was first applied by Ochsner in the preoperative treatment of diffuse appendiceal peritonitis. In this condition he advocated complete rest of the bowel by withholding everything by mouth, gastric lavage if the stomach and intestinal tract were not empty, and the administration of parenteral fluids until the peritonitis had localized or subsided when operation could be done safely. In his hands, in those of Deaver,³ who soon became a staunch advocate of this plan of treatment, and more recently in the hands of Guerry⁴ striking reductions in the mortality of diffuse peritonitis of appendiceal origin were demonstrated.

Nevertheless, although almost half a century has elapsed since it was first advocated, delayed operation has never been adopted by the majority of surgeons. Why has it not been accepted more uniformly? Royster⁵ says that "the Ochsner treatment has been woefully misunderstood" and "dissatisfaction with its results or fatal consequences following its use have come about either through inability to comprehend its principles or to careless execution in its technique." Such misunderstanding may be caused by the fact that Ochsner's descriptions of his plan are not easily accessible and that his followers in this country have not described their technique in detail. Moreover, set rules governing the operation of the plan are difficult to outline, for its successful operation requires judgment which is intangible and does not easily lend itself to a list of didactic rules which may be easily followed. Probably a

more important cause for the lack of popularity of the treatment is the fact that it is more difficult to manage than immediate operation. It necessitates care in selecting cases, close supervision during the course of treatment, and keen judgement in determining when operation should be done once the treatment is started. It requires the sympathetic understanding of the family who usually feel that their procrastination in bringing the patient late may be compensated for by immediate operation, and of the family doctor who may not understand the treatment. And, in addition, it requires the cooperation of the patient who, in the face of continued improvement in his condition, must take nothing by mouth for a longer period of time than he finds comfortable. Such difficulties, we believe, however, are far outweighed by the shorter period of hospitalization, decrease in incidence of complications, and lowered death rate which accompany this form of treatment.

SELECTION OF CASES

Stage of Disease.—There should be no misunderstanding that delayed operation is reserved only for patients with perforated appendices. Whether or not the appendix has perforated in any given case must be determined individually for each patient after a careful analysis of history and physical and laboratory findings. No definite hour after onset of symptoms can be used as a criterion of perforation. While it is true that in most severe attacks of appendicitis the appendix is found to be ruptured forty-eight hours or longer after an attack, it is not wise to set an arbitrary hour, such as forty-eight hours after onset, as a dividing line to separate cases requiring immediate or delayed operation. We have seen one patient in whom delayed operation was justified in the first day of the illness and have seen many in whom immediate operation was indicated four or five days after onset of symptoms. It must be emphasized that, if after careful evaluation of all diagnostic measures there exists a reasonable question as to whether the appendix is or is not ruptured, immediate operation must be done. We have followed this rule rigidly and have found that in our group of 171 cases with perforated appendices in which immediate operation was done 96, or 56 per cent, were in patients with symptoms of forty-eight hours' duration or less. (Table II.)

Differences of opinion exist as to which forms of appendiceal peritonitis should be treated conservatively. Ochsner first advocated his treatment in cases of spreading or diffuse peritonitis. In England, where Sherren first advocated delayed operation in 1905, it has been used largely in cases where localization has already occurred, while patients with diffuse peritonitis, unless moribund, are usually submitted to immediate operation. British surgeons also frequently treat inflammatory masses conservatively for a long period of time. In the United States

TABLE II

DURATION OF SYMPTOMS ACCORDING TO TREATMENT SELECTED—ALL CASES OF PERFORATED APPENDICITIS

| DURATION OF SYMPTOMS | IMMEDIATE OPERATION | | NO OPERATION | | UNSUCCESS- FULLY DELAYED | | TOTAL | |
|----------------------|---------------------|--------|--------------|--------|--------------------------|--------|-----------|---------------|
| | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | MORTAL- ITY % |
| 1 to 24 hr. | 19 | 0 | 1 | 1* | 1 | 0 | 21 | 4.8 |
| 25 to 48 hr. | 72 | 10 | 3 | 0 | 0 | 0 | 75 | 13.3 |
| 49 to 72 hr. | 28 | 3 | 11 | 0 | 1 | 0 | 40 | 7.5 |
| 4 days | 18 | 4 | 8 | 2† | 4 | 0 | 30 | 20.0 |
| 5 days | 9 | 4 | 8 | 0 | 0 | 0 | 17 | 23.5 |
| 6 days | 7 | 3 | 10 | 0 | 1 | 0 | 18 | 16.7 |
| 7 days | 2 | 0 | 4 | 0 | 2 | 0 | 8 | 0 |
| 8 days | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| 9 days | 3 | 0 | 2 | 0 | 1 | 0 | 6 | 0 |
| 10 days | 2 | 1 | 5 | 0 | 1 | 1§ | 8 | 25 |
| Longer | 10 | 1 | 11 | 1‡ | 2 | 2¶ | 23 | 17.4 |
| Total | 171 | 15.2% | 64 | 6.2% | 13 | 23% | 248 | 13.3% |

*Death from general peritonitis.

†Death from pneumonia.

‡Death from retroperitoneal abscess.

§Death from subphrenic abscess.

¶Death from pulmonary embolus.

conservative treatment has been reserved largely for patients with diffuse or spreading peritonitis, and, when inflammatory masses have appeared, early operation has usually been advocated. We have combined these two applications of the conservative regime and now treat all patients with ruptured appendices conservatively, with the exceptions as listed below, regardless of the stage of the peritoneal infection in which the patient is first seen. Our experience (Table I) has been largest in patients with inflammatory masses present on admission. Only two patients with diffuse peritonitis have been treated conservatively. In one the infection localized satisfactorily and was drained. The other patient entered the hospital in the twenty-fifth hour of her illness with signs of generalized peritonitis, maximum in the pelvis, thought to be coming from a salpingitis. Placed on the conservative regime, she seemed to improve, although her temperature and pulse did not fall, and she died on the fifth day of generalized peritonitis. This case, early in our experience, corroborates the observations of Alton Ochsner⁷ and has convinced us that expectant treatment is unwise in the presence of early perforation of the appendix and widespread signs of peritonitis. Such a situation, we now feel, represents the only major contraindication to the use of delayed operation.

Age of Patient.—A. J. Ochsner recognized early in his experience that delayed operation was not borne well by the very young or the very old. Aged patients, he emphasized, do not stand confinement to bed well, while in small children the omentum is not sufficiently developed to act as a protection. This opinion has been modified by Alton Ochsner⁷

who recommends the conservative regime in children in whom localization of the peritoneal infection is beginning. And more recently it has been reversed by the experience of Coller and Potter⁸ at the University of Michigan and Adams and Bancroft⁹ at the University of Minnesota who have found the use of delayed operation advisable in children with diffuse as well as localized appendiceal peritonitis.

Coller and Potter⁸ in 1934 reported a series of 48 children with diffuse peritonitis treated conservatively with a mortality of 12.5 per cent. Although recognizing that the delayed form of operative treatment is less efficient in children than in adults, as is any form of treatment in this age group, their results using delayed operation were superior to immediate operation and they recommend the use of the conservative regime in all patients with diffuse peritonitis regardless of age. Adams and Bancroft⁹ in 1937 reported 110 children with appendiceal peritonitis treated conservatively. Sixty-seven of these patients had generalized peritonitis. Sixty-one per cent developed inflammatory masses, only 10 per cent of which formed abscesses which had to be drained. Ninety-five of the remaining cases subsided completely and were discharged to return for interval appendectomy in eight weeks. The mortality in this series of 110 cases was 4.5 per cent.

Our practice has been to treat children with appendiceal peritonitis conservatively only when localization is already beginning, and to use immediate operation for children with diffuse peritonitis. We have used the conservative treatment in 15 children (Table III). In 11 of these, symptoms and signs subsided entirely and the patients left the

TABLE III

AGE DISTRIBUTION ACCORDING TO TREATMENT SELECTED—ALL CASES OF PERFORATED APPENDICITIS

| AGE | IMMEDIATE OPERATION | | NO OPERATION | | UNSUCCESS- FULLY DELAYED | | TOTAL | |
|--------------|---------------------|--------|--------------|--------|--------------------------|----------------|-----------|-------------|
| | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | MORTALITY % |
| 1 to 5 yr. | 8 | 5 | 1 | 0 | 0 | 0 | 9 | 55.5% |
| 6 to 10 yr. | 22 | 4 | 3 | 0 | 2 | 1 ¹ | 27 | 18.5% |
| 11 to 15 yr. | 35 | 5 | 7 | 0 | 2 | 0 | 44 | 11.4% |
| 16 to 20 yr. | 28 | 1 | 13 | 1* | 1 | 0 | 42 | 4.8% |
| 21 to 30 yr. | 55 | 1 | 12 | 0 | 2 | 0 | 69 | 8.2% |
| 31 to 40 yr. | 16 | 2 | 12 | 0 | 0 | 0 | 28 | 7.2% |
| 41 to 50 yr. | 15 | 2 | 6 | 1† | 4 | 1* | 25 | 16.0% |
| 51 to 60 yr. | 11 | 3 | 6 | 2‡ | 1 | 0 | 18 | 27.7% |
| 61 to 70 yr. | 1 | 0 | 2 | 0 | 1 | 1* | 4 | 25% |
| 71 to 80 yr. | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0% |
| Total | 171 | 15.2% | 61 | 6.2% | 13 | 23% | 245 | 13.3% |

*Death from generalized peritonitis.

†Death from retroperitoneal abscess.

‡Death from pneumonia.

§Death from subphrenic abscess with rupture through diaphragm.

¶Death from pulmonary embolus.

hospital without operation, to return in three months for interval appendectomy. The remaining 4 failed to improve and were operated upon on an average of eight days after admission. One died of a subphrenic abscess which ruptured through the diaphragm. All the others recovered.

In children with diffuse peritonitis, it has been our practice to use immediate operation. Jones and Menefee,¹⁰ in an analysis of all cases of appendicitis in our children's ward between 1930 and 1935, found our mortality in 12 children with generalized peritonitis, all treated by immediate operation, to be 42 per cent. In the past three years 11 children with generalized peritonitis have been treated, 10 by immediate operation and 1 by delayed operation. Five of those subjected to immediate operation died. We are not satisfied with this result which contributes largely to our mortality of 42.8 per cent in all cases of diffuse peritonitis treated in the past three years (Table IV). And in the future we intend to follow the practice of Collier and Potter and Adams and Bancroft and treat children with generalized appendiceal peritonitis conservatively the same as adults.

TABLE IV

ANALYSIS OF ALL CASES OF PERFORATED APPENDICITIS SHOWING THE IMPROVEMENT IN MORTALITY RATE IN THE PERIOD 1934-1937 WITH CONSISTENT USE OF THE CONSERVATIVE REGIME WHEN INDICATED EXCEPT IN CASES OF DIFFUSE PERITONITIS IN CHILDREN

| 1930-1934 | LOCALIZED PERITONITIS | | ABSCESS | | DIFFUSE PERITONITIS | | TOTAL | |
|------------------------|-----------------------|--------|-----------|--------|---------------------|--------|-----------|--------|
| | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS | NO. CASES | DEATHS |
| Immediate operation | 34 | 3 | 45 | 5 | 18 | 8 | 97 | 16 |
| Unsuccessfully delayed | 0 | 0 | 7 | 3 | 0 | 0 | 7 | 3 |
| No operation | 6 | 1 | 11 | 1 | 1 | 1 | 18 | 3 |
| Total | 40 | 10% | 63 | 14.3% | 19 | 47.4% | 122 | 18% |
| 1934-1937 | | | | | | | | |
| Immediate operation | 31 | 2 | 30 | 2 | 13* | 6 | 74 | 10 |
| Unsuccessfully delayed | 2 | 0 | 3 | 0 | 1 | 0 | 6 | 0 |
| No operation | 7 | 0 | 39 | 1 | 0 | 0 | 46 | 1 |
| Total | 40 | 5% | 72 | 4.2% | 14 | 42.8% | 126 | 8.7% |

*Ten of these were in children under 13 years of age, of whom 5 died. The remaining 3 were in adults with symptoms of less than two days. One of these died the day of operation of shock.

Previous Catharsis.—The recent ingestion of cathartics has been stated by Bailey¹¹ to be a justifiable reason for not using the delayed treatment. It is our feeling that such catharsis represents a hazard equally as dangerous if immediate operation were undertaken and we have rarely been influenced by a history of catharsis during the attack. Of our 77 cases treated conservatively, 37 had had catharsis.

Questions of Diagnosis.—When a definite differential diagnosis between perforated appendicitis and some other intra-abdominal catastrophe which requires immediate operation cannot be made, immediate operation should be done. If, on the other hand, the alternative condition suspected does not require immediate operation, indication for delayed operation is all the more certain.

Pregnancy.—Coller and Potter⁸ urge that the delayed form of treatment never be used in pregnant women, stating that the presence of the enlarged uterus prevents localization of the infection. Bailey,¹¹ on the other hand, states that the presence of a pregnancy should not influence one in the selection of suitable cases for delayed operation. We have had no experience with this condition.

Facilities for Care.—It must be emphasized that the conservative treatment of appendiceal peritonitis is not a substitute for operation but a preparation for it. It is not to be undertaken in the home or by the family doctor but in a hospital, "on the threshold of the operating room"¹¹ under the constant eye of the surgeon who is to operate at any hour if necessary. Adequate care can be given satisfactorily in any modern hospital with a trained nursing staff. However, if the surgeon is not so situated that he can visit his patients personally at least three times daily and be prepared to respond at any hour if called, the delayed form of treatment should not be undertaken.

MANAGEMENT OF CONSERVATIVE TREATMENT

Once a patient is selected for the delayed operative treatment, the following regime is outlined:

Fowler's Position.—The patient is kept in bed in Fowler's position with the head of the bed elevated on six-inch blocks.

Nothing by Mouth.—Although Sherren⁶ and his followers in England allow water by mouth, we are convinced of the wisdom of Ochsner's original plan and give absolutely nothing by mouth during the early days of the treatment.

Parenteral Fluids.—A fluid intake of 2,000 to 4,000 c.c. is maintained daily by divided intravenous injections, subcutaneous infusion, or continuous intravenous infusions. Fluids are not administered by rectum nor are large enemas given. Care must be taken that the electrolytes of the blood are not depleted, particularly if constant siphonage of the stomach is maintained.

Gastric Lavage.—If the patient has been vomiting, has eaten recently, or if he is distended, the stomach is washed. If duodenal content is recovered, continuous siphon drainage of the stomach is maintained, using the method of Wangensteen until such drainage stops.

Sedation.—It has been our experience that opiates are seldom necessary. The occurrence of pain during treatment usually indicates that

an abscess should be drained or that the intestinal tract is overloaded and stomach siphonage is necessary. Opiates are used only to allay restlessness or apprehension. We have not used large doses of morphine to increase intestinal tone.

Special Observation.—As soon as the patient is admitted, the extent of abdominal signs is carefully recorded on his chart. If he enters with a palpable inflammatory mass, its exact size is drawn on the abdominal wall with gentian violet. In addition, a special bedside nursing chart is kept on which the nurses record the rectal temperature every two hours, the pulse every hour, and the occurrence of vomiting and pain, as well as the fluid intake, nature and amount of stomach drainage, if any, the urinary output, and the passage of flatus or feces.

CLINICAL COURSE UNDER CONSERVATIVE TREATMENT

There are several possible courses which may be followed by the peritoneal infection under conservative treatment (Fig. 1). They are:

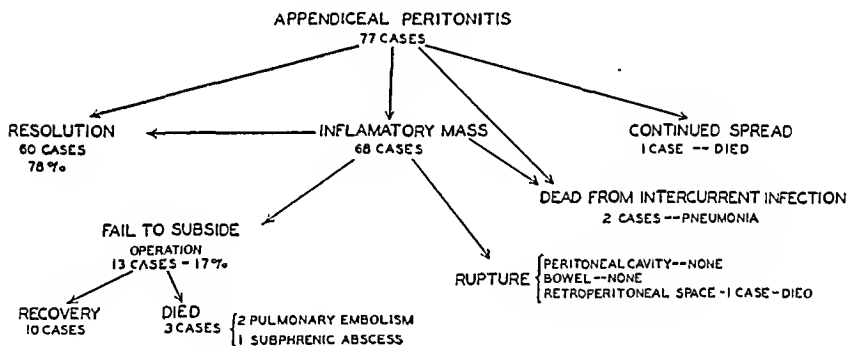


Fig. 1.—Diagram showing the course followed and the result in 77 cases of appendiceal peritonitis treated conservatively. The 77 cases included 2 with diffuse peritonitis, 15 with local peritonitis, and 60 with palpable masses. Of the 60 cases in which signs and symptoms completely resolved and the patients were discharged to return for interval appendectomy, 48 entered with palpable masses and 12 with local peritonitis. Of these 12 cases with localized peritonitis, 5 developed palpable masses which subsided and 7 subsided without first forming a mass. Of the 13 cases which failed to subside and in which operation became necessary, 1 entered with diffuse peritonitis, 2 with local peritonitis, and 10 with palpable masses.

1. The entire inflammatory process may disappear by resolution. This occurred in 60, or 78 per cent, of our 77 cases treated conservatively.

2. The inflammatory process may become localized in the right iliac fossa or in the pelvis, forming a palpable inflammatory mass. Such a mass (a) may then resolve, (b) may fail to resolve or actually increase in size and necessitate drainage, or (c) may rupture into the peritoneal cavity, the bowel, or the retroperitoneal tissues.

3. The inflammatory process may continue to spread and the patient may succumb to a generalized peritonitis.

One must be on the alert for the development of any of these possibilities and if indication of continued spread of the peritoneal infec-

tion or of increase in size or rupture of an abscess occurs, immediate operation must be done.

Resolution of the Peritoneal Infection.—In the majority of patients under the conservative regime of treatment resolution of the peritoneal infection occurs and improvement in the general condition is observed from the start. Vomiting and pain stop, dehydration is overcome, abdominal distention is lessened, tenderness and rigidity of the abdominal muscles decrease, and the temperature and pulse gradually fall.

The continuation of abdominal pain, as is contrasted to abdominal soreness, usually indicates that the appendix is not ruptured or that an abscess under tension is present.

With the complete rest given the gastrointestinal tract and with the use of the indwelling nasal catheter in the stomach, when indicated, abdominal distention has never been a troublesome condition.

The temperature usually subsides slowly and in our experience approximated normal in an average of seven days (Chart I). Maintenance of an elevated temperature in itself for a few days need not be considered abnormal.

The pulse usually falls before the temperature (Chart I). A rising pulse is one of the most important single signs of trouble and usually indicates that the delayed treatment should be abandoned.

If the clinical course progresses satisfactorily, the patient is kept on nothing by mouth until the temperature approximates normal, all distention has disappeared, and he is free of discomfort. Water in amounts of 30 c.c. hourly is then started. If this is not accompanied by abdominal discomfort or rise in temperature, broth, ginger ale, and orange albumin are given in amounts not exceeding 30 c.c. per hour on the following day. This is then increased to 60 c.c. on the next day, clear liquids as desired the next day, and soft diet thereafter during the hospital stay. As feedings are started, the nursing chart, symptoms, and abdominal signs must be watched closely for evidence of a flare-up in the inflammatory process. If at any time abdominal discomfort, increase in abdominal signs, or recurrence of tachycardia or fever appears, all fluid intake by mouth must be stopped. If signs do not then subside promptly, operation must be done. If it is necessary to keep a patient on nothing by mouth for longer than four or five days, as is often the case, transfusions of 500 c.c. of citrated blood are given at one- or two-day intervals. None of our patients undergoing conservative treatment have developed nutritional edema, although we occasionally have seen this in postoperative patients with peritonitis, in whom feeding by mouth has been withheld for a long period of time.

Abscess Formation.—The patient may enter the hospital with a palpable inflammatory mass or one may develop while under treatment.

It is surprising how often large inflammatory masses will disappear completely under the conservative regime of treatment. Such was the case in 53, or 78 per cent, of the 68 patients who either entered with or developed inflammatory masses while under conservative treatment. In 367 cases of appendiceal peritonitis with inflammatory mass treated expectantly, Sworn and Fitzgibbon¹² report 298, or 81 per cent, to have subsided, 13 by evacuation into the bowel. Love¹³ reports 68 per cent of 341 cases and Adams¹⁴ 67 per cent of 214 cases as subsiding completely under the conservative regime.

About 20 per cent of inflammatory masses will not subside and will form abscesses which must be drained. That such an abscess may rupture into the peritoneal cavity must be remembered by all who practice delayed operation. In our series of 68 patients with inflammatory masses on admission or who developed them while under the course of treatment, 13, or 19 per cent, did not subside and were drained at operation, the appendix not being removed in any of these cases. None in our experience have had an abscess rupture into the peritoneal cavity or into the bowel. One patient admitted one month after onset of symptoms died thirty-six hours after admission with a large retroperitoneal abscess.

Close observation of patients with inflammatory masses undergoing the treatment must be maintained so that those with abscesses which need drainage or which might rupture may be selected for operation. Careful evaluation of the temperature, pulse, abdominal symptoms, and size of the abdominal mass must be made frequently. The size of the mass is mapped on the abdominal wall daily and bimanual examination of the pelvis made every two days. The following are taken as indications for operation: (1) The mass is not decreasing in size after four or five days' treatment; (2) the temperature is not subsiding after a week; (3) the mass is growing larger (this is indication for immediate operation); or (4) pain, as contrasted to abdominal soreness, appears. Because of the difficulty in estimating the size of pelvic abscesses, Bailey does not treat abscess in this position expectantly. We feel that bimanual examination of the pelvis can give reliable evidence of the size of pelvic abscesses and have not hesitated to treat abscesses in this position by delayed operation. Coller and Potter draw attention to edema of the genitals as a sign of large intra-abdominal abscesses under tension which require immediate operation. They also feel that a return of elevation in leucocyte count after a preliminary fall during treatment indicates the presence of an abscess.

None of our patients have had an abscess rupture into the peritoneal cavity while under conservative treatment, although Bailey¹¹ reports such a catastrophe. His patient, aged 11 years, seemed to be progressing satisfactorily although the abscess was not decreasing in size. On the fifth day he suddenly collapsed and showed signs of general peritoni-

a mass of adhesions as to make the procedure extremely difficult and hazardous. On the other hand, we have never failed to express surprise at the relative absence of adhesions and the ease of the operative procedure when the appendix is removed three months after the attack.

RESULTS OF DELAYED OPERATION

Mortality.—It is the experience of all who have used the delayed form of operative treatment in appendiceal peritonitis, as outlined, that the mortality rate is significantly reduced. Our seven-year experience with perforated appendices is divided into periods (Table IV). From 1930 to 1934 delayed operation was not used in the early years and in the latter ones only occasionally. This series numbered 122 patients. In the period 1934 to 1937, which includes 126 cases, delayed operation was used in all patients when indicated. The mortality rate in the latter period, 8.7 per cent, was less than one-half that of the 18 per cent of the first period. This reduction was accomplished mainly in the groups of local peritonitis and abscess where the mortality fell from 10 per cent to 5 per cent and from 14.3 per cent to 4.2 per cent respectively.

Guerry⁴ in 1936 reported an operative mortality of 1.4 per cent in 139 cases of diffuse peritonitis treated by delayed operation in contrast to a mortality of 10.6 per cent in 94 similar cases treated by immediate operation. Deaver and Magoun³ report a mortality of 10.5 per cent for all cases with acute appendicitis treated between 1901 and 1905. In the period 1910 to 1914 this fell to 3.7 per cent and between 1915 and 1919 to 4.2 per cent, a reduction which they attributed to the delayed form of operative treatment used in the latter periods. Coller and Potter⁵ report a mortality of 9.4 per cent in 87 cases of spreading peritonitis occurring in patients of all age groups treated by delayed operation. Adams and Baneroff⁶ in a series of 110 children, 67 of whom had generalized peritonitis, report a mortality of 4.5 per cent using the conservative regime of treatment. Stanton¹⁶ reports 113 cases with well-marked evidences of peritonitis. In 31 with immediate operation the mortality was 42 per cent, while 82 were treated by delayed operation with a mortality of 8.5 per cent. Bunch and Doughty¹⁷ in a series of 512 cases of perforated appendicitis treated conservatively when indicated report a mortality of 9.5 per cent. In similar studies Kirtley and Daniel¹⁸ in a series of 308 cases report a mortality of 16.2 per cent and Sperling and Myrick¹⁹ a mortality of 16 per cent in 175 cases.

Sworn and Fitzgibbon¹² report 487 cases of perforated appendices with palpable mass. One hundred and twenty were operated upon immediately and 69 after a preliminary delay with a mortality of 7.9 per cent. In 298 conservative treatment was used and no operation done at the time with a mortality of 0.68 per cent. Love¹³ reports 341 cases of local peritonitis and abscess treated conservatively with a mortality of

tis. Immediate operation was done, drainage was instituted locally and suprapubically, and the patient recovered. Jopson and Pfeiffer¹⁵ report three patients with perforation of an appendix abscess into the free peritoneal cavity, although none occurred in patients hospitalized under the conservative regime. All had had sudden exacerbations of their abdominal symptoms with evidence of a violent peritonitis. Two had also shown evidence of circulatory collapse at the time of the rupture. Operation was done in one case two days after rupture, in another after twelve hours, and in the third in four or five hours. Only the last patient survived. They emphasize that when an abscess perforates into the free peritoneal cavity immediate operation is imperative.

Continued Spread of the Peritoneal Infection.—The process of inflammation within the abdomen may fail to limit spread of infection from a perforated appendix. However, in only 1 of our 77 cases treated expectantly did the infection fail to localize or subside, and the patient, we now recognize, was improperly selected for delayed operative treatment.

If from the onset of treatment abdominal signs do not recede, pain subside, and the pulse rate fall, one should be hesitant to continue the conservative regime. If the abdominal signs are found to be spreading, the pain increasing, or the pulse rising, immediate operation becomes necessary. Bailey draws particular attention to a rising pulse as an indication that the conservative treatment must be abandoned. One need not be alarmed at a maintained temperature for a few days.

WHEN TO OPERATE

The proper time to operate is as important in the successful conclusion of the conservative treatment as is the selection of cases or the management of the regime.

As already indicated, if a localized inflammatory mass is not subsiding or is increasing in size, if an abscess ruptures into the peritoneal cavity, or if continued spread of the peritoneal infection occurs, immediate operation should be done. Fortunately, except in the case of a small percentage of inflammatory masses which do not subside, it is unusual for appendiceal peritonitis not to resolve spontaneously under a properly managed regime of treatment as outlined.

When then should operation be done in the case where the infection is subsiding satisfactorily? Some delay operation only until the peritonitis shows evidence of localizing; others operate as soon as the acute inflammation has subsided, which is usually after eight to ten days of the treatment; while still others wait two or three months after the attack before removing the appendix in an interval stage. We follow the latter form of treatment. Operation in the presence of recent peritoneal infection is too often complicated by the presence of free pus or by such

a mass of adhesions as to make the procedure extremely difficult and hazardous. On the other hand, we have never failed to express surprise at the relative absence of adhesions and the ease of the operative procedure when the appendix is removed three months after the attack.

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3.5 per cent. Immediate operation was done in 1,044 cases of all forms of appendiceal peritonitis with a mortality of 8.8 per cent. Adams¹⁴ in a similar series reports a mortality of 4.2 per cent in 214 cases treated conservatively and 13.2 per cent in 553 cases treated by immediate operation. Bailey¹¹ in 242 cases of all forms of acute appendicitis treated by immediate operation had a mortality of 1.6 per cent. Of 73 cases with appendiceal peritonitis treated conservatively, the mortality was 1.3 per cent.

Complications.—In our series of 60 patients in whom complete resolution of the peritoneal infection occurred without operation, complications developed in 3, or 5 per cent of cases (Table V). In the series

TABLE V

COMPLICATIONS AND DURATION OF HOSPITALIZATION IN CASES TREATED CONSERVATIVELY WITHOUT OPERATION

| | NUMBER CASES | NONFATAL COMPLICATIONS | FATAL COMPLICATIONS AND CAUSE OF DEATH | AVERAGE HOSPITAL STAY NON- FATAL CASES |
|---------------------|-----------------|---------------------------|---|--|
| Local peritonitis | 13 | Ileus 1 | Pneumonia 1* | 17.4 days |
| Abscess | 50 | Recurrence of signs 2 | Pneumonia 1* Retroperitoneal abscess 1* | 15.7 days |
| General peritonitis | 1 | | Peritonitis 1* | |
| Total | 64 | 3 (5%) | 4 | 16.0 days |

*Autopsy performed.

of 145 who survived immediate operation, complications were present in 29, or 20 per cent (Table VII). Sworn and Fitzgibbon¹² report 17.1 per cent complications in their group of appendix abscess cases with operation and 6.7 per cent with conservative treatment.

None of our cases have developed subphrenic abscess or pylephlebitis while under the conservative treatment. Bailey states that subphrenic abscess is almost unknown and that the pylephlebitis does not occur under delayed operative treatment.

Duration of Hospitalization.—That the period of hospitalization is not increased is indicated by the average duration of hospitalization in Tables V, VI, and VII. In patients with appendiceal peritonitis treated by immediate operation, the average hospital stay was 26.1 days. In those whose symptoms subsided completely under conservative treatment, it was 16 days. If to this is added a period of 7 days, which is the average period of hospitalization for interval appendectomy, the total is 23 days. In the group in whom operation was unsuccessfully delayed the total period of hospitalization was 29.7 days.

SUMMARY AND CONCLUSIONS

The delayed form of operative treatment in appendiceal peritonitis is based on sound physiologic and surgical principles. It is indicated in all forms of appendiceal peritonitis regardless of age except in the

TABLE VI
COMPLICATIONS AND DURATION OF HOSPITALIZATION IN CASES IN WHICH CONSERVATIVE TREATMENT WAS ABANDONED
UNSUCCESSFULLY DELAYED

| | NUMBER CASES | DAYS IN HOSPITAL BEFORE OPERATION | NONFATAL COMPLICATIONS | FATAL COMPLICATIONS AND CAUSE OF DEATH | TOTAL AVERAGE HOSPITAL STAY IN NONFATAL CASES |
|---------------------------------|-----------------|--------------------------------------|---------------------------|---|--|
| Local peritonitis Abscess | 2 | 14.0 | None | None | 34.5 days |
| | 10 | 8.7 | None | Pulmonary embolus Subphrenic abscess with rup- ture through diaphragm | 28.8 days |
| General peritonitis | 1 | 5.0 | None | None | 26.0 days |
| Total | 13 | 9.2 | None | 3 | 29.7 days |

SURGERY

TABLE VII
COMPLICATIONS AND DURATION OF HOSPITALIZATION IN CASES WITH IMMEDIATE OPERATION

| TABLE VII COMPLICATIONS AND DURATION OF HOSPITALIZATION IN CASES WITH IMMEDIATE OPERATION | | | | | |
|--|-----------------|--------------------------|---|--|--|
| | NUMBER CASES | NONFATAL COMPLICATIONS | | FATAL COMPLICATIONS AND CAUSE OF DEATH | AVERAGE HOSPITAL STAY, NONFATAL CASES |
| | | | | | 23.1 days |
| Local peritonitis | 65 | | | | |
| Abscess | 75 | Residual abscess | 3 | Peritonitis | 2 |
| | | Ileus | 2 | Pneumonia | 1 |
| | | Femoral thrombophlebitis | 2 | Pulmonary embolus | 1 |
| | | Parotitis | 1 | Subphrenic abscess | 1 |
| | | Massive collapse lung | 1 | | 1 |
| General peritonitis | 31 | Ileus | 4 | Peritonitis | 3 |
| | | Residual abscess | 4 | Pulmonary embolus | 1 |
| | | Fecal fistula | 2 | Multiple lung abscess | 1 |
| | | Femoral thrombophlebitis | 1 | Retroperitoneal abscess | 1 |
| | | Emphyema | 1 | Coronary occlusion | 1 |
| | | Purulent bronchitis | 4 | | 1 |
| | | Ileus | 2 | Peritonitis | 1 |
| | | Residual abscess | 1 | Shock | 8 |
| | | Perirectal abscess | | Parotitis | 3 |
| | | | | Anesthesia | 1 |
| Total | 171 | 29 or 20% | | Residual abscess with rup- ture into peritoneum | 37.2 days |
| | | | | 26 | 26.1 days |

presence of early perforation with widespread signs of peritonitis. Management of the treatment requires absolute rest of the intestinal tract, maintenance of an adequate fluid, mineral, and caloric intake by routes other than by mouth, and careful observation for evidence of continued spread of a peritonitis or rupture of an abscess, in which case immediate operation becomes necessary.

Of 77 patients with appendiceal peritonitis treated conservatively, 60, or 78 per cent, subsided completely in an average of 16 days and were discharged to return for interval appendectomy in 3 months. Thirteen cases failed to subside and formed abscesses which had to be drained on an average of 9 days after admission.

The entire series of 248 cases of appendiceal peritonitis is divided into two periods. In the first, when delayed operation was used only occasionally, the mortality in 122 patients was 18 per cent. In the second period, with consistent use of delayed operation, except in children with generalized peritonitis, this fell to 8.7 per cent in a group of 126 patients. This reduction was accomplished largely in the groups with local peritonitis and abscess where the mortality rate fell from 10 per cent to 5 per cent and from 14.3 per cent to 4.2 per cent respectively.

Failure of reduction in mortality in the group of general peritonitis cases is caused by the fact that in both periods immediate operation was used in all children with diffuse peritonitis. Application of the principle of delayed operation to children with general peritonitis the same as to adults, even though such treatment is recognized to be less efficient in children, we feel would have reduced the mortality in the diffuse peritonitis group.

The complication incidence in survivors of delayed operation was 5 per cent and of immediate operation 20 per cent. The average period of hospitalization of survivors in the group which subsided completely under the conservative regime was 16 days and in the group with immediate operation 26 days.

The reduction in mortality, incidence of complication, and duration of hospitalization in patients with appendiceal peritonitis treated by delayed operation justifies the more widely accepted use of this form of treatment.

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END RESULTS FOLLOWING THE REMOVAL OF AN "INACTIVE" APPENDIX

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IT IS generally agreed that the treatment of the acutely inflamed appendix is its immediate removal. However, it has happened to every surgeon that occasionally, while the history and physical findings have seemed typical of acute appendicitis, an apparently normal appendix was found at operation; furthermore exploration of the abdomen may have failed to reveal any other diseased organ to account for the physical findings. The pathologist, finding no gross or microscopic evidence of inflammation, usually diagnoses such appendices "inactive."

On trying to rationalize the whole situation after operation, the surgeon may wonder if the patient really had appendicitis and if the operation was necessary. However, careful preoperative and operative examination excluded other possible causes. Even laboratory and x-ray examinations of the patient after appendectomy may fail to detect any pathologic condition to account for the symptoms. As a result, the surgeon usually resigns himself to wait and see if the patient develops any symptoms following operation.

The purpose of this paper is to report the results following appendectomy where the patients had the history and physical findings suggestive of acute appendicitis, yet the gross and microscopic examination of the removed appendix failed to show any inflammation (inactive). In this study appendices removed incidentally during the course of some other operation were not included, nor were cases of acute appendicitis treated conservatively at first and then at a later date the appendix removed after the acute inflammation had subsided.

One hundred and forty-three such cases were available for study. These occurred between Jan. 1, 1931, and July 1, 1937. In this same period a total of 1,770 cases of appendicitis was recorded at the University of Minnesota Hospitals. Fifty-three of the subjects were males and 90 females. One hundred nineteen of the cases (83.3 per cent) were under 20 years of age. There was no increased incidence of the disease during any particular time of the year.

All the patients complained of pain in the right lower quadrant of the abdomen. Eighty-one of the patients were nauseated and 71 gave a history of vomiting. Twenty-four had anorexia. Three patients complained of diarrhea, and another 3 had burning and pain on urination.

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Seventy-eight of the patients were seen during an acute attack, of which the duration in 34 cases was less than forty-eight hours. Seventeen of these 78 cases gave a history of one or more previous attacks.

Sixty-five of the 143 cases complained of recurrent attacks of pain in the right lower quadrant of the abdomen. Because the symptoms were not so acute, more detailed study could be given to the patients in this group. Eighteen patients had x-ray studies of the kidney, ureter, and bladder (KUB); 3 were given barium enemas, 1 had a Graham-Cole dye-excretion test of the gall bladder, and 3 had gastrointestinal studies; 9 had x-rays of the chest and 9 had cystoscopic examinations. The results of all these studies were negative.

Physically, there was pain, tenderness, and rigidity in the right lower quadrant of the abdomen in all cases. In 30 per cent of the cases there was a suggestion of rebound tenderness in that region. On rectal examination, one-fourth of the cases complained of tenderness on the right.

The temperature of these patients ranged from 99.2 to 99.4°. In only 1 was the temperature as high as 101.2°. The number of leucocytes in the blood was under 15,000 in all but 9 cases. The highest leucocyte count was 23,500. The total number of polymorphonuclear leucocytes in the blood smear was usually under 80 per cent. In 14 cases it was over 80 per cent, and in 1 the total count was 94 per cent.

Examination of the urine was negative in all but 8 cases, in which albumin, red or white blood cells were found. Seven of these patients had x-ray studies of the kidneys, ureters, and bladder (KUB), and 5 were examined with the cystoscope with negative results.

An appendectomy through a McBurney incision was performed in all cases. There were no deaths in this series.

RESULTS

A letter was written to each patient asking him to come back to clinic for a checkup or to write in his own words how he had felt since his

TABLE I

| | | TOTAL PER CENT | PER CENT AVAILABLE FOR CHECKUP |
|--------------------------------------|-----|-------------------|-----------------------------------|
| Total number of patients | 143 | 100.0 | |
| Failed to reply | 41 | 28.6 | |
| Available for study | 102 | 71.4 | |
| (a) Examined at clinic | 18 | | |
| (b) Replied by mail | 84 | | |
| Recurrence of same or other symptoms | 12 | | 11.7 |
| Felt well since operation | 90 | | 88.3 |
| Felt well less than 1 yr. | 5 | | 2 |
| Felt well 1 to 2 yr. | 19 | | 12 |
| Felt well 2 to 3 yr. | 20 | | 16 |
| Felt well 3 to 4 yr. | 26 | | 19 |
| Felt well 4 to 5 yr. | 27 | | 14 |
| Felt well over 5 yr. | 46 | | 27 |
| | 143 | | 90 |

operation. It was very desirous to contact patients who had been operated upon four or five years previously. A summary of the results is given in Table I.

The salient points of this follow-up are:

1. Of a total of 143 patients from whom an inactive appendix had been removed, 102 replied by letter or were examined in clinic as to their condition since operation. Of these, 90 were well and 12 had had recurrence of the same or other symptoms.

2. Seventy-three of 143 patients had been operated upon four or more years before. Forty-one of these 73 patients were followed; 32 (78.1 per cent) were well, and 9 (21.9 per cent) were not. Those not well were as follows:

TABLE II

| HOSPITAL NO. | SEX | AGE AT APPENDECTOMY | DATE OF APPENDECTOMY | PRESENT COMPLAINT OR DIAGNOSIS |
|--------------|-----|---------------------|----------------------|---|
| 595239 | F | 11 yr. | Aug. 23, 1930 | Still has pain right lower quadrant, especially at pregnancies. |
| 56041 | F | 17 yr. | Oct. 18, 1930 | Still has pain right lower quadrant, especially at pregnancies. |
| 58012 | F | 21 yr. | March 6, 1931 | Pyelonephritis. |
| 634048 | M | 32 yr. | March 9, 1933 | Chronic duodenal ulcer controlled by diet. |
| 632617 | F | 22 yr. | Nov. 8, 1934 | Low back pain; retroverted uterus |
| 616202 | M | 44 yr. | April 16, 1933 | Syphilis |
| 614933 | F | 17 yr. | June 17, 1933 | Bilateral cystic ovaries and right salpingitis (?) |
| 615051 | M | 29 yr. | April 6, 1933 | Psychoneurosis (?) |
| 630245 | F | 24 yr. | Aug. 29, 1934 | Chronic cholecystitis; cholecystectomy, June 24, 1935; still has right lower quadrant pain. |

ANALYSIS OF RESULTS

There are several possible sources of error in this type of study:

1. Personal error: There is always a personal error in tabulating results from a chart if the author has not seen the patient.

2. Accuracy of the pathologic diagnosis: At the University of Minnesota Hospitals, two sections are taken through the intact appendix in this type of case; one through the distal third and one through the proximal third. No inflammation was seen in either section of the appendix.

3. The possibility that the acute inflammation in the appendix had subsided: This is remote as half the cases were operated upon within forty-eight hours after the onset of the acute attack.

4. The size of the series.

5. Manner of the follow-up: All the patients should be interviewed and examined personally.

In the available literature no report of a similar study has been found. C. W. Mayo reported satisfactory relief from symptoms after appendectomy in more than 70 per cent of patients with indefinite pain

on the right side of the abdomen where a careful preoperative examination excluded other palpable causes. The pathologic changes in the appendix were graded "chronic 1, 2, or 3" or "chronic catarrhal."

The question always arises in this type of study as to whether the patient's symptoms were due to a disturbance in the appendix. Clinically there seemed to be no question as to the diagnosis. At least three examiners saw each patient and agreed from the history and physical findings that the patient had appendicitis. "Mass psychology" may have influenced the diagnosis here as in other diseases. If the findings were atypical at all, the general opinion was probably in favor of an appendectomy knowing how treacherous an inflamed appendix may be.

It may be questioned how significant the finding is that 78.1 per cent of the patients followed four years or more after operation were well. The majority of patients from whom an inactive appendix was removed may have recovered without surgical treatment. Certainly a large number of patients who suffer a low grade attack of acute appendicitis may recover from the acute attack without an operation. However, it is not known what percentage of such patients remains well four years or more or what percentage suffers recurrent attacks. No one has apparently thought it worthy of investigation to see what percentage of persons who have had an appendectomy for an acutely inflamed appendix has had symptoms after operation. This would be an important control study.

RATIONALIZATIONS CONCERNING THE "INACTIVE" APPENDIX

How to explain the symptoms in these cases where an inactive appendix is removed is a difficult one. Because the patient obtained relief from symptoms after removal of an organ does not necessarily mean that that organ was the prime seat of the disorder unless relief occurred with frequent consistency. However, if one does not believe the appendix to be at fault, one still has to explain the symptoms in these cases. It is always possible, of course, that some occult lesion elsewhere in the body was the cause of the symptoms, such as duodenal ulcer, pyelonephritis, pelvic inflammatory diseases, etc. The fact that this occurred in only 21.9 per cent of the followed cases makes some other explanation necessary unless one assumes that the primary lesion eventually healed in the other 78.1 per cent.

From the work of Wangenstein and co-workers, it is known that obstruction and infection are two important factors in the etiology of acute appendicitis. However, there was no histologic evidence of inflammation in these inactive appendices. Unfortunately, accurate observations of appendicoliths or other obstructing mechanisms in the appendix were not made. Experimental studies of the cecal appendage of the dog show that infection without obstruction and obstruction without infection (at least, obstruction of the washed cecal appendage of the dog) do not cause appendicitis.

While the appendix and cecal apex are comparable structures, the dog does not have a true vermiform appendix. Only man and the higher primates (chimpanzee, gibbon, gorilla, and orangutang) possess a true vermiform appendix. The rabbit has a vermiform-like cecal appendage but an organ which yet does not satisfy the differential characters of comparative anatomists for a true vermiform appendix (unpublished data, Wangensteen and others). Wangensteen, Dennis, and Buirge have studied the behavior of the vermiform appendix or cecal appendage of man and a large number of animals. Only in man, chimpanzee, and the rabbit does the chief function of the appendage appear to be secretory. In all other animals examined, including the monkey, absorption rather than secretion of fluid appears to be the more important function. In the rabbit, obstruction of the appendix causes a rapid fluid secretion. In ten to fourteen hours the intraluminal pressure may have increased because of fluid production to the extent that rupture occurs. Microscopic study of the cecal appendage of the rabbit showing perforation in consequence of obstruction reveals a histologic reaction similar to that occurring in suppurative appendicitis in man.

In man the appendix shows a definite resistance to intraluminal perfusion, which amounts, on an average, to 38 c.c. of sustained water pressure in a normal appendix, and about 73 c.c. in acute appendicitis. The resistance of the appendix to intraluminal perfusion in patients with appendicostomies is about 47.7 cm. of water pressure. It is interesting that long-sustained increases of intraluminal pressures in the vermiform appendix exteriorized by appendicostomy occasionally cause the patient abdominal pain, nausea, or vomiting. Some of these patients even exhibit slight febrile and leucocytic responses (Wangensteen and others). From these experiments it is a logical conclusion that resistance to the outflow of the appendix is very likely the cause of pain in cases of acute appendicitis.

Wangensteen and co-workers have also shown that experimentally obstruction alone will cause acute appendical inflammation in man, the rabbit, and chimpanzee. In man, obstructive concretions are found in the lumen in a large percentage of acutely inflamed appendices. That acute suppuration of the appendix may occur on the basis of obstruction in the absence of such concretions appears likely in that the appendix apparently behaves like a potential closed loop; that is, there is something akin to a sphincter-like mechanism at its junction with the cecum which interferes with evacuation of material which has found its way into the appendix. When the sphincter-like mechanism at the base of the appendix resists evacuation of its contents, the lumen distends, the intraluminal pressure increases, and the chain of events leading to inflammation of the wall begins.

How the appendix may become totally obstructed in other manners than by appendicoliths or foreign bodies in the lumen of the appendix

has yet to be explained. Wangensteen has suggested that swelling of the mucous and submucous lymphoid tissue may bring about obstruction of the lumen, and also that augmentation of normal physiologic obstruction to emptying by reflex nervous causes may be an etiologic factor.

This last factor may be an etiologic explanation of the symptoms in cases where an inactive appendix is removed. The resistance to outflow due to functional disturbances might reasonably explain the pain. Certainly one would expect to find few if any signs of inflammation in such appendices. Since in other organs functional disturbances may give rise to signs and symptoms similar to those associated with organic lesions, why not in the appendix? Since the appendix serves no useful purpose, the best treatment for disorders of that organ, whether functional or organic, is appendectomy.

Every conscientious surgeon deplures the promiscuous removal of the appendix. However, just because the removed appendix fails to show evidence of inflammation does not mean that the operation was unnecessary. The significance of altered function of the appendix is an important consideration for the pathologist as well as the surgeon. Experimentally, the whole problem of the pathogenesis of appendicitis would appear to start with determination of the various manners in which the appendix may become obstructed. It is suggested that the symptoms in some cases where an inactive appendix is removed may be due to a functional disturbance of the appendix. This possibility demands factual proof.

SUMMARY

Of 143 cases in which an inactive appendix was removed, 102 were available for a follow-up study. Of these, 90 were well and 12 suffered from the same or other symptoms. Of 73 patients who had been operated upon four or more years previously, 41 were followed: 32 (78.1 per cent) were well and 9 (21.9 per cent) were not.

Occasionally the appendix, when removed during what appears to be an acute attack of appendicitis, will show no evidence of acute inflammation. In the light of the results of this follow-up study the surgeon need not feel apologetic over the removal of an appendix inactive from the point of view of the pathologist. It seems quite probable that many patients recover from appendicular colic and fail to exhibit microscopic evidence of inflammation of the appendix.

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TUBERCULOUS PERITONITIS

A SPECULATION ON THE CAUSE OF IMPROVEMENT FOLLOWING SURGERY

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WHEN the words tuberculous or tuberculosis are mentioned, the first thought to come to mind is infection of the lungs, the treatment of which is mostly medical except in the late stages. Tuberculous peritonitis, which may or may not be the primary disease, has for the basis of its treatment surgery. A review of this subject is deemed most timely because of a complete study made on a patient recently operated upon at this hospital.

Faulkner and Everett stated that it was not until the advent of modern surgical methods had led to frequent laparotomies that anything like an adequate idea of the frequency of tuberculous peritonitis and of its various clinical and pathologic manifestations was reached. The first adequate description of the disease in the form of a case report was given by Morgagni in 1744. In the same century two other cases were reported in this country, one by Johnson in 1779 and another by Walther in 1785. The first half of the nineteenth century brought descriptions of the pathologic anatomy by workers interested in tuberculosis (Biehot, Laennec, Boyle, and Louis).

In 1872 Spencer Wells performed a laparotomy in a young woman for what he believed to be an ovarian cyst. He found the typical picture of the ascitic type of tuberculous peritonitis. He simply removed the fluid and closed the abdomen; the patient recovered and was well twenty years after the operation. Thus, we see that surgical treatment of tuberculous peritonitis was found because of a mistaken diagnosis. It was König, in 1884, who noted that four patients recovered following laparotomies as the method of treatment. Subsequent studies by König indicated that laparotomies were curative in this disease. In 1887 Van de Warker in this country, advocated laparotomy in tuberculous peritonitis because of "its possible benefit."

Since Sir William Osler published his monograph, there has been increased study of this disease as indicated by the number of articles appearing in the literature since 1890.

ETIOLOGY

The organisms causing tuberculous lesions are the tubercle bacilli, the human and bovine type being the chief offenders in man. In the United States the death rate from tuberculosis decreased from 195 per

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100,000 in 1900 to 72 per cent 100,000 in 1929. Formerly, tuberculosis stood first as the cause of death, but it is now in seventh or eighth place. The most common method of infection is by inhalation, but transmission by the digestive tract is most common for tuberculous peritonitis. Such infection may take place by direct contamination of food or by indirect contamination by the fingers, flies, and the animals producing milk. Zinsser quoted the U. S. Public Health Service as finding 6.72 per cent of market milk infected with the tubercle bacillus. Ashley found that 50 per cent of cases of abdominal tuberculosis are due to the bovine bacillus.

C. H. Mayo wrote, in 1929, that we have gradually learned of the bovine type and its method of transmission to man through milk. Thus, tuberculosis of the bovine type represents at least 25 per cent of the tuberculosis in children and is found on the farms and in small towns and villages. He stated that England and Scotland have paid greater attention to bovine tuberculosis and believes their statistics are better than ours. Tuberculosis of the tonsil, cervical lymph glands, appendix, and mesenteric lymph glands may be foci for peritoneal tuberculosis. Colt and Clark stated that when a local tuberculous process is very active and a caseous gland ruptures, local or general tuberculous peritonitis ensues.

INCIDENCE

Faulkner and Everett found an incidence of 2.8 per cent in 7,000 autopsies. These authors agreed that the disease is more common in females. C. H. Mayo explained that involvement of the pelvis in women may be caused by tuberculosis of the oviduct. He wrote that reports of necropsies showed more than twice as many males as females affected with tuberculous peritonitis, but probably three times as many females as males are operated upon for this condition. Osler believed the disease more common among colored people, but the consensus now, according to literature, is that the frequency is about the same in the two races.

The greatest age incidence occurs between the ages of 20 and 40 years, but it may occur at any time of life. There is an absence of a history of tuberculous contact in these patients, according to Faulkner and Everett.

PATHOLOGIC TYPES

Eliason wrote that from the standpoint of the surgeon the disease is best indicated as being of the exudative or wet type, the adhesive or dry type, and the suppurative type. Further classification into the acute and chronic is necessary as it is generally conceded that the fulminating or acute types are not amenable to surgical intervention.

SYMPTOMS AND DIAGNOSIS

Tuberculosis of the peritoneum may present a variety of clinical manifestations, depending on the acuteness or chronicity of the type. Osler pointed out that symptoms may be latent. Faulkner and Everett showed the chief complaint of pain was abdominal or lower abdominal in 95 of 161 cases. Other symptoms given as the chief complaint were varied, but abdominal swelling and weakness were the most frequent.

The acute form may occur suddenly, especially in children, with chills, temperature of 101 to 105° F., headache, vertigo, malaise, nausea, vomiting, abdominal pain, distention, tenderness, rapid pulse, anorexia, leucopenia, and rapid ascites as the usual symptoms. Rapid ascites is a significant diagnostic point, according to Eliason. The digestive symptoms are far from specific, according to Faulkner and Everett. Nausea and vomiting are inconstant. Constipation or constipation alternating with diarrhea is stressed by some authors. We know, also, that other diseases may cause symptoms of the digestive tract similar to these. Weakness and susceptibility to fatigue should always arouse one's suspicions of tuberculosis. Urinary symptoms, such as dysuria, frequency, and hematuria, should be investigated for a tuberculous origin. Murphy stressed the fact that in the serous ascitic variety of the disease alternate remissions and exacerbations of symptoms are frequently observed.

Faulkner and Everett conclude from their own experience "that the presence of abdominal swelling and distention, particularly if there is definite ascites and a history of pleurisy, associated with abdominal pain or pelvic pain which is worse at the menstrual periods, with a low grade fever, higher toward evening, and loss of weight, with some digestive symptoms especially constipation, and with dysuria or frequency, or both, constitute a syndrome which should strongly arouse the clinician's suspicions of peritoneal tuberculosis."

About 27 per cent of these can be diagnosed preoperatively. Those most easily diagnosed are the ones with ascites and abdominal tenderness. Examination by pelvic route may show palpable masses, tenderness, or distention. The diagnosis is very easily missed because the condition is not kept in mind.

TREATMENT

The proper treatment is the combination of general treatment of tuberculosis and the intelligent use of surgery. General treatment consists of the proper dietary and hygiene, and the employment of ultraviolet rays.

Surgical treatment has to offer several procedures of laparotomy alone, laparotomies with eradication of focus, paracentesis with removal of fluid, paracentesis with removal of fluid followed by the injec-

tion of air or oxygen. Tuberculous peritonitis should never be drained because of the possibility of a fecal fistula's developing.

Stein, in 1934, recommended oxygen pneumoperitoneum whether the condition was primary or of genital or intestinal origin. This method may be combined with the use of iodized oil instillation. Both are of diagnostic and of therapeutic value.

Savage, in 1928, wrote that treatment of tuberculous peritonitis could be accomplished by administration of ether anesthesia. He stated that surgeons frankly admit that results in this disease are out of all proportion to the surgical work done and have advanced one or more of the following theories to explain their cures: trauma, liberation of fluid with or without drainage, decrease in intra-abdominal tension, admission of sunlight, atmospheric air and the actinic sun ray. He remarked that it was strange that no one had considered anesthesia. Savage reported seven patients, one of whom died, all having been treated by closed ether anesthesia for thirty to fifty minutes without operation. The fatal case was puzzling to the author so he looked to a pathologic explanation. He found that there are three stages of the disease: the first stage is one of passive congestion; the second is that of small, isolated, glistening tubercles; and the tertiary stage is that of the large gray tubercle which tends to caseate and coalesce. Investigation by the author showed that the patient with the tertiary stage was the one who died.

Savage saw a girl aged 4 years and 7 months in consultation with Dr. George B. Twitcheil, of Cincinnati, Ohio. This girl had been ill from November, 1914, to March, 1915. Twitcheil, who did not believe Savage's ideas on the treatment of tuberculous peritonitis, agreed, after they had talked to the girl's mother, to try the ether anesthesia. It was agreed that if improvement did not come at once, surgery would be resorted to. The child was given ether anesthesia for thirty minutes. The verbatim record of the improvement follows: "On the morning following the anesthetic, so the mother stated, she ate more than she had for one week. During the ten days immediately following the anesthetic, indiscretions in diet necessitated free purgations on two occasions. Her periods of sleep lengthened; on the fourteenth (March, 1915), four days following the anesthetic, she slept the entire night and so continued. Her restlessness and night cries ceased and she assumed a natural prone position in bed. Her temperature did not go above normal after the anesthetic. Her convalescence was not interrupted and her recovery was complete."

Savage believes that chloroform would give the same results but that gas anesthetics will to a less extent. He concluded that the earlier the anesthesia is applied, the better are the results, but when there is no response to the ether anesthesia, no hope for relief can be expected from any form of treatment.

The following case reports have been taken from the files of the Robert Packer Hospital.

CASE REPORTS

CASE 1.—A white female, aged 65 years, was admitted to the hospital Nov. 27, 1937, with the chief complaints of loss of weight and distress or heavy feeling in lower abdomen. She stated that since July, 1937, she had been losing weight. Her normal weight was 145 pounds and her weight one month before admission was 135 pounds. Her appetite had been poor through the summer months but had improved some at the time of admission. Her bowels had been regular and she had had no spells of diarrhea. She had a distressed feeling in the lower abdomen which she said was not pain but a feeling of distention or gas; this distress was not associated with or made worse by intake of food and was worse at times and then seemed to improve. She said that she did not have any ambition and felt rather weak at times and that for six weeks prior to admission she had been having severe night sweats.

Her menopause had occurred twenty-eight years before and she had noted no spotting since that time. Since the onset of the present illness, she had had some vaginal discharge which required wearing a napkin irregularly. She had borne one child during thirty-seven years of married life. She had no frequency of urination, but had nocturia once a night regularly. There had been some attacks of dizziness and palpitation.

Examination showed a well-developed and nourished female. The chest, spine, and extremities gave no findings. The heart rate was 87 and the blood pressure was 180 systolic, 90 diastolic. There was a loud systolic murmur but no evidence of decompensation. The abdomen gave an impression of a doughy mass in the lower portion, and pelvic examination gave the impression of the same sort of doughy mass, which was suspected of being malignant.

Laboratory studies revealed: Urine, specific gravity 1.020 to 1.027, acid, and occasional pus cells; red blood cells, 4,420,000; hemoglobin, 84 per cent or 13 gm.; white blood cells, 11,600 with 88 per cent polymorphonuclears and 12 per cent lymphocytes. Her serology was negative, while the blood urea was 55 mg. and the blood sugar 118 mg. per 100 c.c. Widal and undulant fever agglutination tests were negative.

On Nov. 30, 1937, laparotomy was performed. At operation it was found that the pelvic organs and intestines in the lower abdomen were densely adherent by innumerable, rather firm adhesions. The parietal peritoneum and that covering the organs was profusely studded with small discrete pearly tubercles; no excess peritoneal fluid was found. No attempt was made to free the adhesions. The diagnosis from this laparotomy was tuberculous peritonitis. The anesthesia was changed from ethylene to ether and was administered for thirty minutes. The wound was closed in the usual way.

Following the operation, the patient's convalescence was uneventful, with very little distention. On Dec. 10, 1937, a Mantoux test was done and was found to be one plus positive. Again, on Dec. 15, 1937, a bovine tuberculin test was performed. On the day following the administration of the test, the patient was stricken by a severe chill followed by a temperature rise to 102.8° F. The temperature gradually subsided and was down to its former level, ranging between 98 and 99.5° F. in twenty-four hours. During this reaction the patient suffered anorexia, weakness, malaise, and severe sweats. In two or three days all symptoms were gone. The bovine test was read as three plus positive. It was concluded from the character of the reactions of these two tuberculin tests that this patient's infection was of the bovine type.

Röntgenograms of the lungs were taken Dec. 18, 1937, to rule out any pulmonary focus. The films showed increased bronchovascular markings but no evidence of parenchymal lesions of the lungs. The aortic arch was shown to be calcified.

This patient was seen and examined in the clinic on Jan. 26, 1938, at which time she had regained much of her weight and strength.

CASE 2.—A white female, aged 13 years, came to the clinic on July 28, 1928, complaining of pain in her abdomen of twelve hours' duration. She was awakened late at night by pains in her lower abdomen. The pain localized in the midline. The patient had no nausea or vomiting, but a progressive distention of the abdomen had been noticed. For four or five days previous to her present illness, she had not been feeling up to par and for one week previously she had had a profuse vaginal discharge.

Her temperature on admission was 101° F. with a pulse rate of 124. The cheeks were flushed and the patient appeared acutely ill. The abdomen was markedly distended and extremely tender. She was considered to have an acute appendicitis which was probably perforated. Operation was advised and a diffuse tuberculous peritonitis was found. The abdomen was closed and closed ether anesthesia was given for thirty minutes. The patient was discharged Sept. 23, 1928, much improved. Five years later (1933), the patient returned with the same set of symptoms. This time she was considered to have a recrudescence of the tuberculous peritonitis although her abdomen was not opened; closed ether anesthesia was administered for one hour and recovery was prompt. The patient has since been in good health with no recurrence of symptoms.

On Dec. 27, 1937, this patient was asked to report to the clinic for a check-up. She stated she had been symptom free and that she had had no recurrence of the symptoms of tuberculous peritonitis. About one year ago she had married and shortly after developed an infection in her left kidney. A left nephrostomy was performed at another hospital. In view of this recent left pyonephrosis, we were anxious to know whether or not it was of tuberculous origin. A communication from the hospital in which she was operated upon indicated that one quart of pus was drained from this kidney, that the pus was sterile by culture, and that kidney function was markedly diminished.

CASE 3.—This white female, aged 31 years, came to the clinic Jan. 19, 1927, with the complaint of bloating of the abdomen, noticeable for about three weeks before admission. She had vomited a few times and her bowels had not moved since the onset of the present illness. She had some pains in both groins. Headaches had been severe and frequent during this present illness. She had a nocturia of three or four times, but no frequency during waking hours. At this admission she stated she had been in this clinic eight years previously, at which time she was operated upon and was told that she had tuberculous peritonitis.

Examination at this second admission showed the abdomen to be quite distended and slightly tympanitic. There was general tenderness, especially so in the right lower quadrant. The abdomen was fluctuant. Vaginal and rectal examinations gave no clue to the diagnosis.

In view of the previous history of tuberculous peritonitis, the patient was considered to have a recrudescence of the tuberculous lesion. She was given closed ether anesthesia for thirty-five minutes and five days later her temperature had returned to normal from an admission temperature of 102.4° F.

She returned for a check-up on March 2, 1927, with her condition much improved and with a weight gain of six pounds. Again, on April 4, 1927, she was seen and stated that she felt excellent; her abdomen was flat and she was allowed

to return to her work. The family physician of this patient reported that she was in good health four or five years ago but that he had been unable to follow her since that.

CASE 4.—A white female, aged 24 years, came to the hospital July 26, 1926, complaining of pain in the right upper abdomen. For years she had had attacks of acute indigestion at infrequent intervals. She claimed she had had an attack of jaundice which lasted one month. She had no pain at this time but considerable gas and indigestion. There was epigastric soreness one month before admission. The day before admission she had a sharp pain in the right upper quadrant, following which she developed soreness in the lower abdomen. The patient complained of nausea but no vomiting. She was severely constipated. Examination at this time showed nothing except slight upper abdominal tenderness. Her temperature on admission was 98° F., but within twelve hours she developed a chill and her temperature rose to 102.4° F. Laboratory tests gave no clue to the diagnosis.

In view of the history and findings a laparotomy was performed under ethylene anesthesia on July 31, 1926. Through a right rectus incision the abdomen was explored and found to be filled with straw-colored free fluid. All peritoneal surfaces were studded with myriads of small tubercles and a large mass was located in the central part of the abdomen. The abdomen was closed without drainage and without further exploration.

Convalescence was rapid and by the sixth postoperative day the temperature had reached normal levels; she was discharged on the seventeenth day, much improved. A report through her family physician in 1929 indicated that she was in good health and working every day. Because of the death of this girl's family physician, we have been unable to bring her follow-up study to date, as she has moved to California.

CASE 5.—This patient, a white female, 48 years old, came to the clinic Jan. 31, 1927, with the complaints of anorexia and insomnia. She had been well until Dec. 25, 1926, when she suddenly lost her appetite and had some nausea. She had some dyspepsia and was disturbed by a considerable amount of gas. Epigastric discomfort and a heavy feeling in the abdomen were noted. About twenty-one years previous to this time, she stated, she had a similar attack which lasted five weeks. The patient had been eating at boarding houses and hotels. Her menses were regular until six months before this illness, when they stopped. Ten days before her admission there had been a vaginal discharge which was slightly bloody. She had noted a rise in her temperature varying from 99 to 101° F. Insomnia was a prominent complaint.

Examination on admission gave signs enough to suspect a lesion of the right apex. Roentgenograms examined stereoscopically showed the lungs to be clear. Laboratory studies did not aid in making a diagnosis. The patient was suspected of having tuberculous peritonitis and closed ether anesthesia was administered for thirty minutes. She was not subjected to surgery. Twelve days following the anesthesia the patient was much improved and she was discharged from the hospital three weeks after the ether was given.

A check-up examination at the clinic one month after she left the hospital showed much improvement with a normal temperature, increase in weight, and improved appetite. On Nov. 17, 1927, the patient had continued to feel well and had regained her strength.

This patient returned to the clinic Feb. 23, 1938, and she was entirely symptom free. An undulant fever agglutination was negative as was her physical examination.

COMMENT

Since the results of surgery in tuberculous peritonitis are out of proportion to the amount of surgical work performed, there must be some explanation of why these patients improve. Also, it seems likely in some cases that equivalent improvement may be accomplished by the use of closed ether anesthesia alone. A temporary anoxemia produced by the anesthesia might be an explanation for the apparent cures.

The tubercle bacilli are known to be aerobic organisms. Zinsser and Bayne-Jones wrote that the best growth is obtained under conditions allowing free access of oxygen of the air. It has been shown that wax plugs in culture tubes inhibit or reduce the bacterial growth by restricting the oxygen supply. The admission of air by laparotomy, if the peritoneal cavity can be considered as a live culture tube, should enhance the growth of the infecting bacilli. Such a circumstance could hardly be offered as an explanation of improvement after surgery on that basis alone. The application of closed ether, chloroform, or nitrous oxide anesthesia, on the other hand, would produce a temporary anoxemia. Reasoning, again, from the known facts of culturing the tubercle bacilli, the reduced oxygen intake of the body would explain, at least partially, the improvement that follows when ether anesthesia alone is administered.

The chemical study of the tubercle bacillus shows that such compounds as lipoids, fatty acids, acetone-soluble fat, and wax can be isolated. Since the blood carries a large volume of ether vapor during anesthesia, it is possible that some chemical reaction may take place with one or more of these substances to cause permanent injury to the organisms or to produce an oxygen impermeable membrane about them. Such speculations on a chemical basis would tend to uphold further the proposed theory of anoxemia as an explanation of convalescence of tuberculous peritonitis cases following closed ether anesthesia alone or accompanying a surgical procedure.

A study of cases of tuberculous peritonitis which have been operated upon under spinal anesthesia would do much to settle the question of whether inhalation anesthesia is a factor in the improvement.

SUMMARY

The available literature on tuberculous peritonitis has been reviewed. Tuberculous peritonitis treatment is not medical nor surgical but is a combination of both.

The only article available on the treatment of tuberculous peritonitis by closed ether anesthesia has been reviewed.

Comment has been made as to the possible explanation of the therapeutic action of ether anesthesia in tuberculous peritonitis.

From experiences in this hospital, as indicated by case reports and by the writings of Savage, of Cincinnati, it appears ether anesthesia is a valuable adjunct in the treatment of tuberculous peritonitis.

The postoperative condition of patients who have been operated upon under spinal anesthesia and gas anesthetics, which do not produce anoxemia, should be studied.

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CHRONIC SUBDURAL HEMATOMA

DIAGNOSIS AND TREATMENT

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THE condition known today as chronic subdural hematoma was first described very accurately by Virchow¹ in 1857 under the name of "hematoma durae matris" or "pachymeningitis hemorrhagica interna." He based his studies in most part on autopsy material and concluded the lesion to be spontaneous in origin due to an inflammatory condition which was progressive in type. He described the formation of a very vascular subdural membrane followed by ecchymosis and subdural hemorrhage. He recognized a traumatic type, chiefly in the newborn, but made no comparative studies between the two types. Much interest was aroused by Virchow's work and the condition was studied extensively by Huegenin,² Wiglesworth,³ Robertson,⁴ Schuberg,⁵ and many others. With few exceptions their chief object was to determine the underlying pathology and little attention was directed to the proper treatment of the lesion. Although Schuberg, as early as 1859, recognized trauma as a cause of chronic subdural hematoma, little attention was paid to its significance until 1914, when Trotter's paper⁶ was published. He stated: "It is nearly certain that the veins passing from the brain to the tributaries of the superior longitudinal sinus are always the source of the blood." He explained in detail the mechanism by which this bleeding was produced, and by so doing I believe he gave us a proper conception of the true cause, which is in most cases traumatic.

Putnam and Cushing⁷ in 1925 described two classes of subdural hematoma. The first they called a vascular or spontaneous type, and the second, a reactive or traumatic type. The slight histologic difference between the two types is hardly sufficient to justify the distinction.

Spiller and McCarthy⁸ in 1899, working on cats and dogs, produced the lesion experimentally by nicking the superior longitudinal sinus sufficiently to produce a subdural hemorrhage. They studied the formation of the hematoma in sacrificed animals at intervals varying from sixteen hours to five weeks and found the new membrane was present in a few days and distinctly formed in five weeks.

Interest in the early diagnosis and treatment of this particular lesion has been greatly stimulated in the past ten years by reports of cases and groups of cases cured by surgical methods. Excellent articles by Jelsma,⁹ Kaplan,¹⁰ Gardner,¹¹ Fleming and Jones,¹² McKenzie,¹³ Kee-

gan,¹⁴ Coleman,¹⁵ Frazier,¹⁶ Furlow,¹⁷ and many others have proved to us that chronic subdural hematoma is a curable surgical condition.

The gross appearance of the lesion as well as the pathology of the sac and its contents has been exhaustively considered in the literature, and I shall not attempt to describe them in detail here. Briefly, the lesion is an encysted clot under the dura and when exposed at operation can hardly be mistaken for any other condition, so characteristic is its appearance. The subdural sac with its liquid and clot contents presents a dark greenish blue appearance through the dura. In the late stages this outer wall may present a greenish yellow appearance due to presence of deposits of bile pigment. In most cases the sac is very extensive,

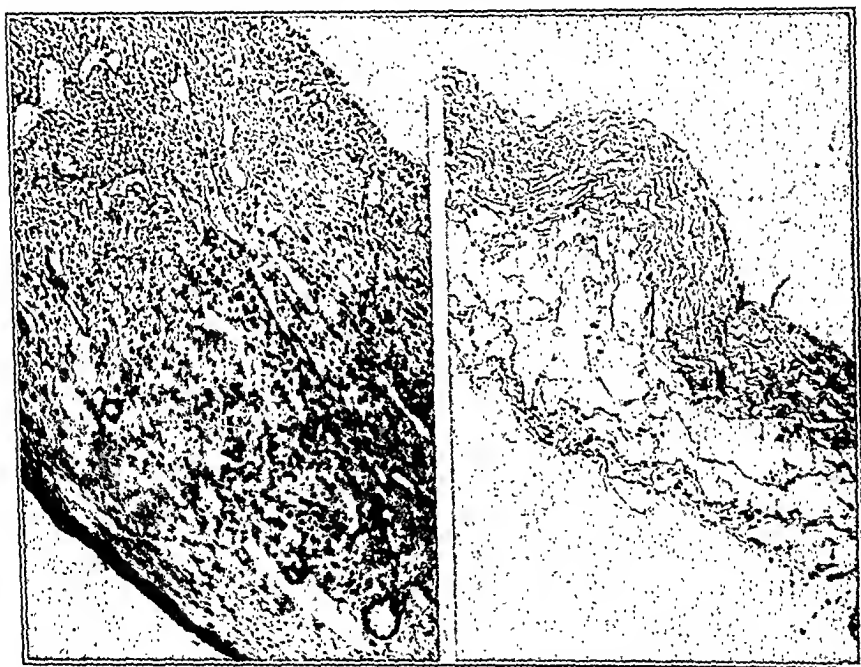


Fig. 1.—(Case 2.) Photomicrographs showing (left) outer wall of sac and (right) inner wall of sac for a subdural hematoma.

covering a large portion of one hemisphere from the frontal pole to the occipital lobe and from the midline down to the Sylvian fissure or below it. The dura usually can be separated readily from the outer wall of the sac. When the sac is opened, dark reddish brown liquid escapes and one may find rusty looking clots in various stages of liquefaction. The inner wall of the sac lies directly over the arachnoid. It is thin and transparent and not adherent to the arachnoid except at its border, especially in the region of the longitudinal sinus. (Fig. 1.) Bleeding may be encountered in this area if an attempt is made to remove this portion of the sac. When the sac and its contents have been removed, the brain presents a flattened appearance and is pushed away from the

dura one inch or more, depending on the size of the clot. The hemisphere appears compressed and does not expand readily to its normal contour. If the hemisphere appears to expand and fill up the space when the sac is removed, a similar lesion on the opposite side should be suspected. (Fig. 2.)

The clinical course of this condition is not always typical, but in a majority of cases the history will disclose the following sequence of events. A history of a trivial blow on the forehead or occiput or a glancing blow over the vertex can often be obtained. This usually is followed by symptoms of slight concussion lasting only for a short period. The patient recovers promptly from the immediate effects and



Fig. 2.—(Case of unsuspected subdural hematoma found at autopsy.) Photograph of convexity of brain showing marked compression of the right hemisphere. The dura over the right hemisphere is folded back over the left hemisphere to show the sac of the subdural hematoma.

may resume his former activities with no apparent symptoms. Several weeks or more may elapse before the lesion reaches sufficient size to cause the patient to complain. The first symptoms to appear are those of slowly increasing intracranial pressure of one or both hemispheres. Headache is the first symptom to appear and is usually persistent, although it may vary in intensity from day to day. Generally it increases and is of a throbbing type. Nausea and vomiting may occur along with the headaches.

Along with these complaints, mental changes appear which are often noted by the patient's relatives and friends. The patient becomes dull, inattentive, and forgetful. Personality changes are often noted. Re-

mission and exacerbations are noted from time to time. Later a state of stupor appears, followed by coma. Even in this stage remissions and exacerbations are striking. The patient may pass alternately from coma to consciousness and may appear and act quite normal when conscious.

The following case (Case 1) presents a typical history, as well as the confusing neurological signs often noted:

CASE 1.—E. B., white male, aged 29 years, was admitted to the University Hospital on Aug. 4, 1936, and discharged on Sept. 29, 1936. This patient was in an automobile accident two months before admission to the hospital. He sustained a head injury at the time and was unconscious for a short time. He was treated at home and remained in bed for one week following the accident, at which time he was able to go back to work. He worked for about a month before any symptoms appeared. At this time he developed headache and nausea with blurring of vision and diplopia. His family also stated that he became very forgetful and was at times completely disoriented.

Physical examination on admission showed the patient to be a well developed, slightly obese young man, somewhat disoriented and complaining of severe headache. The positive neurological findings were dull mentality, bilateral anosmia, difficulty with taste for several weeks, bilateral reduction in visual acuity, bilateral choked disks with hemorrhages, slight ptosis of right internal rectus muscle, partial third nerve palsy, diplopia on looking to left, tongue protruding slightly to the left, questionable reduction of motor power in right arm and right leg, slight ataxia in both lower extremities, knee and ankle jerks absent bilaterally, and Oppenheim positive on the left. A diagnosis of subdural hematoma over the right hemisphere was suspected.

On Aug. 27 a small trephine opening was made in the right occipital region over the posterior horn of the lateral ventricle preparatory for a ventriculogram. When the dura was opened in this region, a subdural hematoma was encountered. A right osteoplastic flap was immediately turned down and a large subdural hematoma exposed. The entire sac and its contents were removed and the patient showed marked improvement for ten days, and then began to have headache and blurring vision, and became very drowsy. A spinal puncture at this time showed a clear fluid with increased spinal fluid pressure. Since the patient had improved so promptly following the removal of the sac and had later developed symptoms of increased intracranial pressure, hemorrhage at the site of the operation or a similar lesion on the opposite side was suspected. Since the spinal fluid was clear and the entire sac had been removed on the right side, it was deemed wise to explore the left hemisphere even though there were no localizing signs present.

On Sept. 16 under local anesthesia a trephine opening was made in the left temporal region and a subdural hematoma found over this hemisphere. A second trephine opening was made in the frontal region and the dura and sac opened. The contents of the sac were evacuated by irrigating with salt solution. Both incisions were closed without drainage. The patient made a very prompt, uneventful recovery and was discharged well on Sept. 29, 1936.

The neurological picture is one of generalized increased intracranial pressure. Rarely are there definite focal symptoms. The slow compression of a large part of a hemisphere may and does occasionally produce a gradually increasing paresis to the face, arm, and leg, but rarely is there a paralysis. Jacksonian attacks are practically never seen, but

convulsive seizures may occur late in the course of the illness. Slow pulse is common; cerebrospinal fluid is often under increased pressure and may be either clear or xanthochromic. Early in the course of the lesion the eye grounds appear normal; later, however, there is a mild venous congestion of the disks, followed by a gradual obscuration of the margins and a total absence of the cups.

The symptoms in general conform fairly well to those produced by a slow, progressive, expanding lesion over a large portion of one or both hemispheres without local cortical irritation.

Evidence to support the slow, progressive type of lesion is produced in a case of Coleman,¹⁵ in which an exploration through a small burr opening was negative. There was temporary improvement followed by return of symptoms. An exploration through the same opening eleven days later revealed the lesion which he explained "had evidently moved forward under the exploratory opening in the eleven-day interval."

McKenzie¹³ suggested that the increase in the size of the sac was due to a process of osmosis, the sac acting as a semipermeable membrane. As the encysted clot disintegrates, the protein content is changed, thereby increasing the osmotic pressure within the sac. Cerebrospinal fluid then dialyzes through the inner sac wall from the subarachnoid space to restore the osmotic balance. Zollinger and Gross¹⁶ recently have supported this view by some convincing experimental evidence on intact membranes removed surgically. Recurrent bleeding into the sac either from the vein originally injured or from granulation tissue of the dural wall, as suggested earlier by Trotter,⁶ Putnam and Cushing,⁷ Keegan,¹⁴ and others, probably plays some rôle in producing the slowly expanding lesion.

If a subdural clot is suspected, the diagnosis should be at once verified or ruled out by burr openings over both hemispheres, for in a certain percentage of cases the lesion is bilateral. Air injection is seldom necessary, but it may be helpful when some other lesion is suspected (Fig. 3).

Several surgical procedures have been advocated in the treatment of chronic subdural hematoma: (1) the use of a large osteoplastic flap with the removal of the entire sac and its contents, (2) the evacuation of the clot through small burr openings, and (3) the removal of a clot through a subtemporal decompression opening. Very satisfactory results have been reported in a large number of cases by simple drainage through small burr openings. It is not necessary to remove the sac to effect a cure. Bilateral perforations should be accepted as the method of choice for several reasons: (1) because the procedure is a simple one and can be carried out in a short period of time under local anesthesia, without loss of blood and without shock to the patient; (2) because the one procedure serves to establish the diagnosis, to determine whether the lesion is bilateral, and to evacuate the clot; and (3) because it enables one to evacuate a bilateral hematoma at one sitting. When there

is a well-organized clot present, it may be necessary to reflect a flap to remove it effectively.

Drainage, I believe, is not necessary when the clot has been removed by irrigation and suction through burr openings, unless there is indication at the time of operation of fresh bleeding. In such cases a small tubular drain should be left in each perforation as a precautionary measure, in case of subsequent bleeding.

According to most investigators, cerebral edema is the most important complication to be feared. Postoperative edema was not suspected or proved in any of the fourteen cases reviewed for this discussion.

Postoperative extradural hemorrhage is more likely to occur than cerebral edema, especially when there is no increased intracranial pres-



Fig. 3.—(Case 1.) Photographs of patient showing results of operations for bilateral subdural hematoma three weeks following bone flap and one week after trephine operation on opposite side.

sure and when a dead space persists after the evacuation of a clot. This complication occurred in only one of the fourteen cases of our series.

Probably the most important postoperative pathology which exists is the failure of the compressed brain to expand promptly. This, together with the accumulation of fluid in the dead space, has been described by Coleman¹⁵ to be the cause of the stormy, delayed convalescence seen in many cases. This condition has been encountered repeatedly in this series of cases. The duration of the lesion, no doubt, is a determining factor, for in other cases with little compression the convalescence was surprisingly rapid and free from complications. (Fig. 4.)

Marked circulatory changes were noted frequently on the surface of the compressed hemisphere after removal of the sac. The vessels were flattened and did not fill promptly when the pressure was removed. In

one case (Case 2) petechial hemorrhages were found in the brain stem. These circulatory changes due to long-continued, slowly increasing intracranial pressure are perhaps responsible for the long-delayed, stormy convalescence seen in cases which come to operation late in the course of the lesion. (Fig. 5.)

In the following case (Case 2) secondary vascular changes were noted and probably had some bearing on the outcome.

CASE 2.—J. S., aged 52 years, white male, was admitted to the University Hospital on Feb. 13, 1936, and died on Feb. 15, 1936.

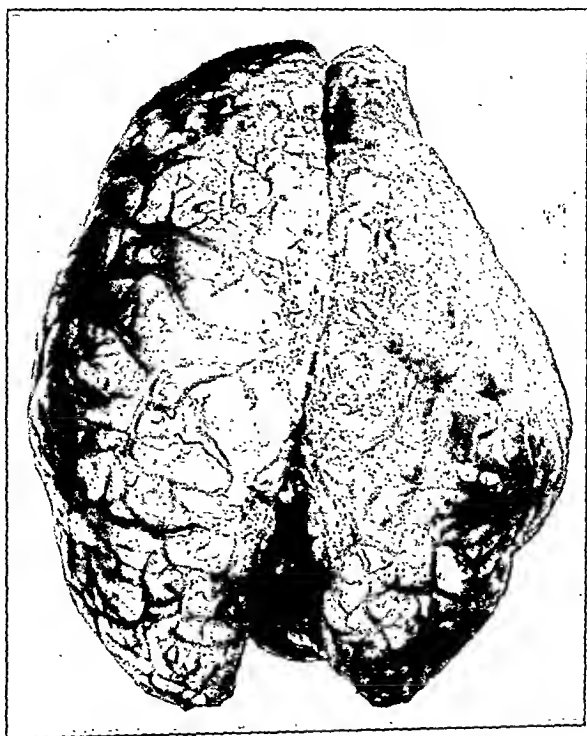


Fig. 4.—(Case 2.) Photograph of brain showing extreme compression of the right hemisphere and secondary vascular changes.

This patient gave a history of having been in an automobile accident two and one-half months before admission. He sustained a laceration over his right eye and was unconscious for about ten minutes. He was taken to a hospital in the vicinity where the laceration was treated and he was discharged. The patient returned to the hospital for dressings on several occasions and apparently was in good health and had no symptoms. He continued his work on the farm until about a week before admission to the hospital. During this period he had only slight attacks of headache and apparently only during the last two weeks had any other symptoms. His family noticed that his memory was failing and that he became untidy and appeared mentally confused at times. One week before admission he became very drowsy and it was difficult to arouse him for several hours. The following day he appeared normal and went about his work. Four days before admission he fell in the yard un-

conscious. He remained in an unconscious state for twelve hours, gradually regaining consciousness until he was able to take fluids by mouth and respond to questions. He was taken to the hospital at this time and later transferred to the University Hospital in Baltimore for treatment. On admission to the hospital he was in a comatose condition and could not be aroused. There were marked signs of dehydration.

On examination the patient's attention could not be kept. He went to sleep very easily, had no idea as to his whereabouts, and knew no one. He had no phobias or hallucinations. Examination of the cranial nerves was as follows: 1, apparently had no anosmia; 2, visual acuity appeared to be normal, but could not be tested adequately; visual fields normal on rough test; slight choking; 3, 4, and 6, pupils round, regular, and central; reacted to light and accommodation; no apparent nystagmus; extra-ocular movements normal; 5, muscles of jaw appeared normal; sensitive to pain and temperature; 7, face was drawn slightly to right, left eyelid seemed to be ptosed; 8, hearing apparently normal; 9 and 10, could swallow; voice normal; pulse slow; 11, negative; 12, tongue protrudes in midline without tremor.

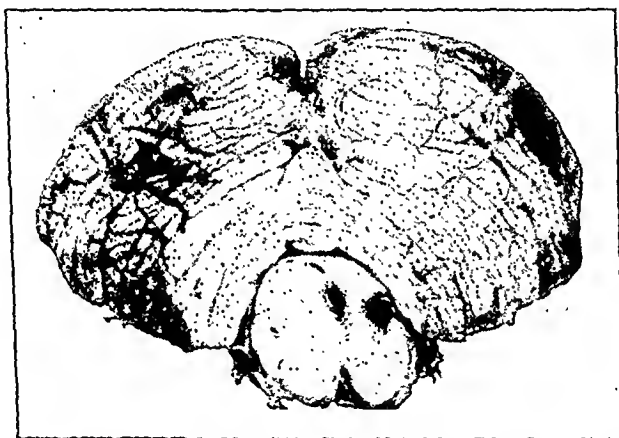


Fig. 3.—(Case 2.) Photograph showing hemorrhage in the brain stem.

The entire left upper extremity was weaker than the right, but there was no tremor, convulsions, or atrophy. The left lower extremity was also weaker than the right.

The physical examination of this patient was as follows: Head: Scalp showed several ridges over parietal and occipital regions on the left. Ears: Showed no tophi, discharge, or mastoid tenderness. Eyes: See under cranial nerves. Nose: Breathing spaces adequate, septum in midline and intact; mucous membranes red-
dened, slight serous discharge. Mouth: Sordes over lips; tongue coated; teeth carious; throat injected. Neck: Enlargement of lymph glands in anterior and posterior angles. Chest: Expansion limited; percussion note impaired over entire left area, but very slight. Breath sounds vesicular and roughened throughout lung area. Fine râles heard throughout both lung fields. Heart: Appears normal in size and contour to percussion. No shocks or thrills; rate is slow, regular in rhythm and intensity. No murmurs. Blood pressure, 125/90. Abdomen: Flat, soft. No rigidity or tenderness. Liver, spleen, and kidneys not palpable. No masses.

The roentgen examination of the skull showed an average-sized cranium, bones moderately thick. The vessel markings appeared normal. The sella was small,

TABLE OF REFLEXES (CASE 2)

| REFLEX | RIGHT | LEFT |
|--|----------|--------|
| Jaw jerk | 0 | 0 |
| Biceps jerk | + | + |
| Supinator jerk | + | + |
| Triceps jerk | + | - |
| Abdominal— | | |
| Upper | + | + |
| Lower | + | + |
| Cremasteric | + | + |
| Knee jerk | + | + |
| Ankle jerk | + | + |
| Ankle clonus | 0 | 0 |
| Plantar | Extensor | Flexor |
| Brudzinski | 0 | + |
| No cervical rigidity or Kernig sign elicited | | |

closed-in variety. There was no radiable evidence of any pathologic change. There was no evidence of fracture.

The laboratory findings were as follows: Urinalysis: Specific gravity 1.030; reaction acid; no sediment, albumin, sugar, acetone; microscopically negative. Blood count: Hb., 99 per cent; Sahli, 15.84 gm.; R.B.C., 5,870,000; W.B.C., 10,450; color index, 0.8; Differential count: Filamentous polymorphonuclears, 61; nonfilamentous, 17; lymphocytes, 14; large mononuclears and transitionals, 8.

A diagnosis of a right subdural hematoma was made. On Feb. 14 a right osteoplastic bone flap was turned down. A large subdural hematoma was found and the sac and its contents removed without difficulty. There was no bleeding at the time of operation, but the whole hemisphere showed a very marked compression and failed to expand when the clot was removed. The flap was replaced with the patient apparently in fair condition. He failed to react, however, following operation. His temperature became elevated and his pulse remained quick. A spinal puncture was done several hours following the operation because postoperative hemorrhage was suspected. The spinal fluid was found to be clear and the pressure was 100 mm. of water. The patient died twenty-four hours after operation.

At autopsy the right hemisphere of the brain showed marked compression and distortion, due chiefly to the inability of the brain to expand after the removal of the subdural hematoma. The parietal and frontal lobes were chiefly affected, but the temporal lobe was also slightly involved. There was a localized area of subarachnoid hemorrhage which extended from the superior temporal convolution to the longitudinal fissure, and anteriorly just in front of the Sylvian fissure and posteriorly to the paracentral lobule. The operative specimen which was removed from the right hemisphere measured 10 by 4.5 by 3 cm. This consisted of a sac of fibrous tissue and had much the same appearance as the dura, except that it was not quite so tough. The membrane was semitransparent and smooth on both surfaces. The mesial wall of the cyst was very much thinner than the lateral wall. The mesial wall had the appearance almost of cellophane; whereas, the external wall was hemorrhagic in color and much thicker.

Section through the optic chiasm showed the right lateral ventricle to be compressed and the septum pellucidum was displaced to the left. The right hemisphere was compressed, as previously described. Both hemispheres showed convolitional flattening due to a marked degree of intracranial pressure. A section through the peduncles showed a vertical hemorrhage 5 mm. below the aqueduct in the midline. This hemorrhage measured 6 by 2 mm. At the periphery of the left peduncle there was another hemorrhage which measured 5 mm. A section through the pons and

cerebellum at the fifth nerve exit showed a small hemorrhage 5 by 2 mm. in the midportion of the pons. Section through the pons at the eighth nerve exit showed a small hemorrhage measuring 3 by 1 mm. on the left side in the lateral portion.

Microscopic examination of the limiting membrane of the subdural hematoma showed a loose, eosin-tinted matrix, embedded in which were numerous round cells, the whole evidently being granulation tissue. There were numerous thin-walled spaces lined by a single layer of cells, but a few well-developed blood vessels were also present. There was condensation of connective tissue fibers on one surface, forming the limiting membrane. Free red blood cells were found in the tissue in small areas. In the microscopic section through the peduncles and aqueduct, the aqueduct contained a few red blood cells. In the middle of the peduncular structure there was an old hemorrhage with some destruction of nerve tissue. The leptomeninges in the interpeduncular space contained numerous pigment granules embedded in the fixed tissue cells of the leptomeninges. There was no cell infiltration. Some recently extravasated blood was also present here. Some perivascular edema was also present in the section.

In the microscopic section through the right superior frontal convolution there was old hemorrhage in the leptomeninges, with hyalinosis of the vessels. The usual thickening and the presence of hemocyteron granules were also noted. The underlying cortex showed no change except edema. There was some lack of clearness in the staining of the nerve cells. The subcortical fiber tracts showed no edema. In the right middle frontal convolution there was a slight amount of old hemorrhage together with edema in the leptomeninges, the presence of a few plasma cells containing pigment, and a few round cells also pigmented in the depths of the sulci. On the surface of the gyri the old hemorrhage was dense, the blood cells disorganized, and numerous small round cells and some polymorphonuclear leucocytes were seen. The amount of free blood pigment gave a dusty appearance. At no place did the hemorrhage break through into the cortex. The limiting membrane of the cortex was a little thickened and did not show rupture. Edema was visible throughout the slide, but there were no areas of softening in the nerve tissue.

Microscopic section of the left middle frontal convolution showed the leptomeninges to be quite edematous. All the blood vessels were engorged but showed no changes in their walls. The underlying nerve tissue was also edematous in both the cortical and subcortical fiber tracts. The basilar artery showed no pathologic change. In the left basal ganglia no change was noted except for perivascular edema.

In this series of 14 cases of subdural hematoma on which this paper is based, there were 2 deaths. One patient (Case 2) died after a flap operation; the other death (Case 10) occurred following the evacuation of the clot through a subtemporal decompression opening. History of trauma was obtained in 12 of the 14 cases. There were 10 males and 4 females in the group. The clot was on the right side in 8 cases and on the left in 6. Only 1 had bilateral clots. The Wassermann reaction was negative in every case.

Choked disks were present in 5 cases. The spinal fluid pressure in the 9 cases without choked disks was increased and in 4 of these 9 cases the fluid was xanthochromic. Headache was the most common complaint and was present in all cases. Mental disturbance was a prominent symptom in 10 cases. Vomiting was not frequently present and occurred in only 4 cases. Paresis of the cranial nerves and extremities was not a common finding. Coma was present in only 2 cases.

A flap operation was used in 7 cases. In 4 the clot was removed through one or more burr openings. Subtemporal decompression openings were used in 3 cases. A secondary flap operation was necessary to remove a solid clot in 1 of the latter group. In the 1 bilateral case a flap operation was done on one side and the clot evacuated through burr openings on the other.

The diagnosis in 10 cases was suspected from the history and verified by burr openings. Air injection led to the diagnosis and localization in 4 cases in which other lesions were suspected. Pincal gland shift was noted in 1 case. (Fig. 6.)

CASE 3.—C. A., white male, aged 24 years, was admitted to the University Hospital on Aug. 1, 1935, and discharged on Aug. 24, 1935.

The patient gave a history of having been in an automobile accident on April 25, 1935, three months before admission. He received a sharp blow on the head just

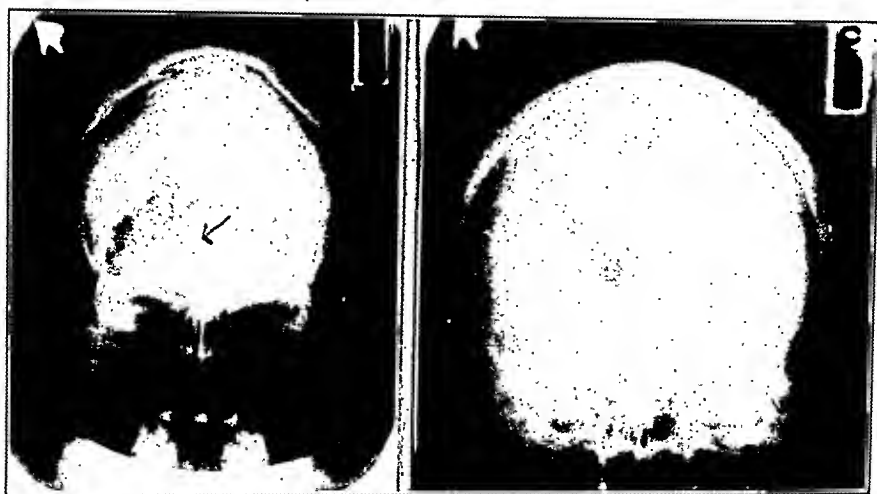


Fig. 6.—(Case 3.) Air injection showing shifting of the ventricular system, distortion of the ventricles, and pineal gland shift.

over the left eye. He was unconscious for about one-half hour and remained in the hospital for three days. After discharge from the hospital, he was able to go back to work and stated that he felt entirely well until July 26, about a week before he entered the hospital. He then developed severe frontal headaches and blurring of vision. On admission, his only complaint was severe headache. The neurological examination was entirely negative except for bilateral choked disks. The tentative diagnosis of subdural hematoma or brain tumor was made.

Three days after admission a ventriculogram was made and showed a marked displacement of the lateral ventricles to the right beyond the midline with compression of the left lateral ventricle. On Aug. 5, a left osteoplastic bone flap was turned down and a large subdural hematoma extending from the frontal pole to the occipital region was found. The sac with its contents stripped readily from the dura and underlying cortex, except a small portion close to the midline in the frontal region where it was apparently attached to the longitudinal sinus. In removing the sac in this area there was considerable bleeding from the tributaries going into

the longitudinal sinus. Before replacing the flap, this bleeding was completely controlled. The entire hemisphere was compressed and showed little evidence of expanding after the sac was removed. The patient made an uneventful recovery and was discharged cured twenty-three days after admission.

CASE 4.—A. E. W., white male, aged 26 years, was admitted to the Maryland General Hospital on Oct. 14, 1936, and was discharged on Nov. 5, 1936.

The patient gave a history of injury to the head in an automobile accident six weeks prior to this admission to the hospital. He was not unconscious, but received first aid treatment at the hospital and was then discharged. He had no symptoms until four weeks after injury when he complained of a generalized headache. Several days later the headaches were more severe and were accompanied by nausea and vomiting. On admission to the hospital the patient was stuporous, but he could be aroused. He was well oriented as to time and place. There was a small scar on the vertex of the head which was well healed. There was a very definite right facial weakness and marked choking of both disks. The neurological examination was otherwise negative.

The spinal fluid was clear with a pressure of 35 mm. of Hg, and a cell count of 3. From the history a subdural hematoma was suspected over the left hemisphere. Under local anesthesia a small trephine opening was made in the upper temporal region on the left side. The dura and cortex appeared normal. The same procedure was carried out on the right side with the same findings. A third trephine opening was made in the occipital region over the posterior horn of the right lateral ventricle, preparatory for a ventriculogram. When the dura was exposed in this area, it appeared bluish in color and when opened there was an escape of dark brownish red fluid. A large amount was evacuated through this small opening and a diagnosis of subdural hematoma was made. No attempt was made to empty the ventricle or to inject air. The sac was allowed to empty itself without irrigation and the incisions were closed without drainage. It was felt at the time that a secondary operation would probably be necessary if there were solid clot present. The patient, however, made a very prompt, uneventful recovery and was discharged in good condition on Nov. 6, 1936.

CASE 5.—M. McK., colored woman, aged 32 years, was admitted to the Baltimore City Hospitals on March 2, 1937, and was discharged on April 21, 1937.

The patient gave a history of a head injury about three months previous to admission. She was not unconscious at the time, but was taken to a hospital where a laceration of the scalp was sutured. She returned to her home and continued her work for almost two months, during which time she had intermittent headaches but not enough to interfere with her work. One month following the injury to her head she was taken to the Sydenham Hospital in a semicomatose condition. Examination showed positive blood and spinal fluid Wassermanns, and a diagnosis of central nervous system syphilis was made. She was transferred to the Baltimore City Hospitals for treatment.

Her neurological symptoms varied from time to time. At one time there was a very definite left facial weakness, mental reaction was very slow, and she complained of headache. On another examination there was a definite right facial weakness, rigidity of the right arm was present, and there were tremors of the right upper and lower extremities. The eye grounds were normal and there were no signs of increased intracranial pressure.

On March 18 a spinal puncture was done. The fluid was clear, with a pressure of 350 mm. of water. One hundred cubic centimeters of fluid were removed and replaced with air through the spinal needle. Encephalography showed marked distortion of the ventricular system. Both lateral ventricles were

displaced to the left of the midline, the left being slightly dilated and the right showing marked compression. The tentative diagnosis of subdural hematoma was made with the alternative of expanding glioma. On March 19, two small trephine openings were made under local anesthesia in the upper temporal and frontal regions on the right side. The dura was exposed and showed a bluish appearance. When opened, a typical subdural hematoma sac was disclosed. When the sac was opened, a large amount of brownish red fluid was evacuated. The sac was irrigated until the irrigation was returned clear. There was no solid clot present. The incisions were closed without drainage. The patient made a very prompt, uneventful recovery.

CASE 6.—H. L., white male, aged 61 years, was admitted to the Church Home and Infirmary on May 20, 1930, and was discharged on June 4, 1930.

The patient gave a history of head injury three months previous to admission to the hospital. While trying to halter a bull, he was thrown against the side of the stall, striking the right side of his head. He was not unconscious, but felt dizzy for ten to fifteen minutes. Following this injury he had intermittent headaches for four to five weeks. The headaches gradually disappeared until three weeks prior to his admission to the hospital, when he suddenly became unconscious while on an automobile trip. He regained consciousness about a half hour later, but remained very drowsy and complained of severe headache until the time of admission. The history obtained from the family showed that his memory had become affected during this three-week period, and at the time he was disoriented as to time and place.

On admission to the hospital, the patient's attention could not be aroused and he was completely disoriented. The neurological examination showed the following positive findings: (1) bilateral choked disks with hemorrhages; (2) exaggerated deep reflexes, left upper and lower extremities; (3) positive Babinski on the left side; and (4) muscle weakness, left upper and lower extremities. A diagnosis of subdural hematoma was suspected, but the possibility of a tumor could not be ruled out. The patient therefore was prepared for a ventriculogram, and under local anesthesia a small trephine opening was made over the posterior horn of the right lateral ventricle. When the dura was exposed, it appeared bluish green in color and when incised there was an escape of dark brownish red fluid. A diagnosis of subdural hematoma was made immediately and the ventriculogram was not done. Under local anesthesia a right subtemporal decompression was done. A portion of the sac of the hematoma was resected and its contents evacuated by irrigation with salt solution, and two small rubber tissue drains were placed in the sac before the incision was closed. The patient drained a considerable amount of dark brownish fluid for several days, after which the drains were removed. He made an uneventful recovery and was discharged from the hospital on June 4, about two weeks after admission.

CASE 7.—J. H., white male, aged 56 years, was admitted to the Mercy Hospital on Dec. 31, 1934, and was discharged on March 1, 1935.

The patient was admitted to the hospital following a head injury sustained in a fall from a ladder. He vomited several times on admission and complained of severe headache. There was a laceration of the scalp in the left parietal region and ecchymosis and swelling of the left upper lid. The neurological examination was entirely negative. X-ray examination of the skull showed a linear fracture in the left frontal region extending into the parietal and occipital bones.

The patient was kept under observation in the hospital for sixteen days. During this period his headaches continued and at times he showed very marked mental confusion and slight elevation of temperature, with a pulse rate ranging between 70 and 90. Spinal puncture on Jan. 5 showed xanthochromic fluid under a pressure of 330 mm. of water. There was no definite change in the patient's condition fol-

lowing the puncture. A diagnosis of subarachnoid hemorrhage was made and several spinal punctures were done during the next ten days. The pressure gradually decreased and on Jan. 15 it was 90 mm. of water, but the fluid had become more xanthochromic, and it was felt that the patient had a clot over the left hemisphere or a subdural hematoma.

On Jan. 16 a left osteoplastic flap was turned down. The external surface of the dura appeared normal, but when an incision was made through the dura there was a free flow of yellow fluid. This fluid was found to be encysted in a sac which was very firmly adherent to the dura. The outer wall of the sac was dark in color and was so tightly adherent to the dura that it had to be removed with the eurette. The ventral wall of the sac was made up of thickened pia-arachnoid and the fluid was encysted in an area about 15 cm. in diameter. The sac was only partially removed after its contents had been thoroughly evacuated and the operative field washed with salt solution. The wound was closed without drainage. The patient's convalescence was slow and was marked by symptoms of mental confusion, which were the last to disappear.

CASE 8.—M. McK., colored woman, aged 38 years, was admitted to the Baltimore City Hospitals on Sept. 1, 1935, and discharged on Oct. 8, 1935.

Four days before admission the patient complained of severe headache, became very drowsy, and two days later became irrational. When admitted to the hospital, she was in a semicomatose condition, with a temperature of 102° F., and a pulse rate of 112. There was cervical rigidity, and bilateral choked disks were present. The neurological examination was otherwise negative. The white blood cell count was 17,980. Lumbar puncture showed a clear fluid under a pressure of 250 mm. of water. An encephalogram showed the lateral ventricles markedly displaced to the left beyond the midline, with compression of the right ventricle downward. There was no history of injury obtained and the condition was rather acute for a subdural hematoma. The encephalogram, however, suggested this diagnosis and on Sept. 10 two small trephine openings were made in the right parietal and frontal regions and a subdural hematoma was found. The contents of the sac were evacuated through these two openings and the sac irrigated with salt solution. The incisions were closed without drainage. The patient made an uneventful recovery and was discharged on Oct. 8, 1935.

CASE 9.—M. B., white woman, aged 71 years, was admitted to the Hospital of the Women of Maryland on Feb. 12, 1935, and discharged on March 21, 1935.

One and one-half months before admission to the hospital, the patient tripped and fell down the cellar stairs. There was a small laceration of the scalp and the patient was rendered unconscious for several minutes. She was confined to her bed for ten days following her injury. Her only complaint at this time was pain in the back of the neck. She gradually developed a weakness of the right arm and leg, and one week before admission to the hospital she fell two or three times, due to weakness in the leg. She then developed a severe headache accompanied by mental disturbances and loss of memory. There were also a speech disturbance and incontinence of bowel and bladder. Several days after admission the patient's condition improved somewhat, but she suddenly fell into a comatose state and appeared acutely ill. Lumbar puncture on Feb. 20 showed a xanthochromic fluid under increased intracranial pressure. An encephalogram showed a shifting of the lateral ventricles to the right with a compression of the left ventricle and a slight dilatation of the right.

A diagnosis of subdural hematoma was made. On Feb. 20 under local anesthesia a small trephine opening was made in the left temporal region, and a typical subdural hematoma was found. A second trephine opening was made in the frontal

region and the contents of the subdural hematoma washed out through these two openings. Both incisions were closed without drainage and the patient made a very slow uneventful recovery.

CASE 10.—J. A. R., white man, aged 63 years, was admitted to the West Baltimore General Hospital on Jan. 13, 1932, and died on Feb. 13, 1932.

The patient was admitted three days following an automobile accident in which he was rendered unconscious. He developed headache, pain in the back of the neck, and there was an occasional spell of vomiting. His headache continued until Jan. 19, when he became difficult to arouse. Spinal puncture on Jan. 19 showed a xanthochromic fluid under markedly increased pressure. The patient seemed to improve slightly following the puncture, but the next day he became very drowsy again. He was thought to have a subarachnoid hemorrhage and on Jan. 22 a second spinal puncture was done. At this time the fluid was still xanthochromic, under increased pressure, and contained 11 cells per c. mm. He again improved for a period of six days, at the end of which time he became delirious, attempted to get out of bed, and his temperature and pulse were elevated, and he showed signs of meningitis. A third spinal puncture was done on Feb. 2 with practically the same findings as before. Several days later he developed a slight weakness in his right arm and leg, with increased reflexes on the same side.

On Feb. 5 a small trephine opening in the left temporal region disclosed a subdural hematoma. This trephine opening was gradually enlarged under the temporal muscle and the sac evacuated by washing with salt solution. Two rubber tissue drains were inserted and the wound closed. The patient reacted very well following the operation, recovered the use of his right arm and leg, became cheerful, quiet, and cooperative. Six days following the operation, he had a recurrence of his original symptoms and signs, together with elevation of pulse and temperature. The original incision was reopened on Feb. 12 and the sac explored. There was a collection of greenish yellow fluid in the sac. This was evacuated. A culture from the cystic fluid showed short-chain streptococci. The patient did not react after the second operation and died the following day with streptococcal meningitis.

CASE 11.—A. S., colored man, aged 74 years, was admitted to the University Hospital on Nov. 16, 1933, and discharged on Feb. 3, 1934.

The patient gave a history of falling on a porch and striking his head on a concrete pillar. He was not unconscious at the time and was able to go about his work almost immediately after the fall. Several weeks later he began to have severe headaches accompanied by dizziness and a tendency to fall forward. The patient gradually developed mental changes, became very untidy, and at the time was disoriented.

On admission to the hospital the patient showed a healed laceration over the left eyebrow, early choking of both disks, weakness in the left upper and lower extremities, and a slight left facial weakness. Lumbar puncture showed a clear fluid with a spinal fluid pressure of 300 mm. of water. A chronic subdural hematoma was suspected and on Nov. 28, 1933, a right subtemporal decompression was done, and a hematoma was drained through this incision. The patient showed marked improvement for two weeks following operation. At the end of this time, he suddenly developed signs of increased intracranial pressure and his old symptoms returned. A diagnosis of recurrent subdural hematoma was made, and on Dec. 29 a right sided bone flap was made and the entire subdural hematoma with the sac was removed. His progress following the second operation was slow, but he eventually made a complete recovery and was discharged about a month following his second operation.

CASE 12.—R. P., white man, aged 57 years, was admitted to the University Hospital on March 12, 1934, and discharged on March 24, 1934.

The patient gave a history of a fall on the ice on Feb. 12, 1934, at which time he sustained a fractured skull. He was not unconscious at the time, but about a week following his injury he showed mental disturbances and difficulty in speech. These symptoms gradually improved until March 12, the date of his admission to the hospital, at which time he suddenly became disoriented as to time and place, was aphasic and very emotional. There was a slight weakness in the right arm and leg; the disks showed early choking; and the neurological examination was otherwise negative.

A diagnosis of chronic subdural hematoma was made and on March 14 a left osteoplastic bone flap was turned down and a large subdural hematoma was removed. The patient made an uneventful convalescence and was discharged ten days after operation.

CASE 13.—N. K., white male, aged 47 years, was admitted to the South Baltimore General Hospital on Aug. 1, 1934, and discharged on Aug. 25, 1934.

The patient gave a history of chronic headaches of two weeks' duration, accompanied by dizziness. The neurological examination was negative except for internal strabismus of the right eye. Lumbar puncture showed a xanthochromic fluid. An encephalogram showed a shifting of the lateral ventricles to the left of the midline, with a compression of the right lateral ventricle and a slight dilatation of the left. A diagnosis of a subdural hematoma was suspected and a trephine opening was made over the right hemisphere and the diagnosis verified. The subdural hematoma, together with the sac, was removed through a flap operation on Aug. 13. The patient made a very prompt and uneventful recovery and was discharged twelve days later. In this case the diagnosis was suspected from the encephalogram and was verified by a trephine opening.

CASE 14.—L. W., white woman, aged 63 years, was admitted to the Union Memorial Hospital on June 3, 1930, and discharged on Aug. 18, 1930.

The patient gave a history of having been injured in an automobile accident nine weeks previous to admission. She was unconscious for only a short time. Five weeks later she developed a speech disturbance and weakness of the right arm and leg.

On admission to the hospital there was a small scar over the right temporal region and increase in the reflexes in the right upper and lower extremities, with a positive Babinski on the right side. A diagnosis of subdural hematoma was made and an operation was done on June 5, 1930. Flap operation was the technique used, and a large subdural hematoma was removed. The entire sac was removed. The patient had a stormy convalescence, but at the time of discharge the speech was normal and she had regained function in her right arm and leg.

CONCLUSIONS

1. The symptomatology of chronic subdural hematoma is extremely variable and misleading.
2. Trauma is the etiologic factor, with rare exceptions and is usually considered trivial at the time of injury.
3. The lesion is more frequent in males than in females.
4. The diagnosis should be suspected or made if there is a history of slight injury followed by headache, mental changes, stupor, or signs of slowly increasing intracranial pressure. There may be a "free interval" of weeks, or even months, following the injury before the symptoms appear.

5. Localization is frequently impossible by neurological signs alone. Pathologic reflexes are common, but usually they are of no localizing value.

6. When subdural hematoma is suspected, dual perforations should be made, for the lesion is frequently bilateral.

7. Bilateral trephine openings should be accepted as the method of choice, because this simple procedure serves (a) to establish the diagnosis, (b) to determine whether the lesion is bilateral, and (c) to evacuate the hematoma. When there is a well organized clot present, it may be necessary to reflect a flap to remove it effectually.

8. It is not necessary to remove the sac to effect a cure.

9. Failure of the compressed hemisphere to expand and vascular changes secondary to long-continued compression are the most serious postoperative complications.

I am indebted to Dr. Charles Bagley, Jr., for granting me permission to include several of his own cases in this series.

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SUBDURAL HEMATOMA, ACUTE AND CHRONIC, WITH SOME REMARKS ABOUT TREATMENT

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OF THE entire group of head injuries, those with subdural hematomas most frequently require a critical decision as to whether or not surgical intervention is necessary, and if so what is the most desirable procedure and when is the most favorable time.

The speeding forces of the machine age, particularly the automobile, have increased enormously the incidence of indirect head trauma, and the proper treatment of these seriously injured persons is a growing responsibility.

During the past two decades, our consciousness about chronic subdural hematoma has been sharpened by the publications of Trotter,¹ Putnam and Cushing,² and more recently by those of Rand,³ Jelsma,⁴ Gardener,⁵ Munro,⁶ Coleman,⁷ Frazier,⁸ Grant,⁹ and others, and we are now more alert to suspect the possibility of a chronic subdural hematoma in the differential diagnosis of comatose patients.

The results following the removal of chronic subdural hematomas are uniformly excellent in all neurosurgical clinics. There are indeed few surgical conditions in which early diagnosis and prompt surgical intervention are followed by such dramatic and complete recovery.

Therein, however, lies a danger. Our enthusiasm about the results with chronic subdural hematomas easily may be carried over to the other head injuries with deepening coma.

Whereas operative interference in patients suffering with chronic subdural hematomas is practically always necessary, this is not true of patients with acute subdural hematomas. Hasty operation on such patients can only end disastrously. The injured person with only a small margin of safety who might well be saved by medical measures may easily have his chances jeopardized by manipulations incident to taking of x-ray pictures, transportation to the operating room, and the added trauma of the operation.*

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*Patients in shock, whether it be the result of trauma, a prolonged and exhausting operation, or an unusual response to some medication, have a small margin of safety which is best reflected by temperature, pulse, and blood pressure readings. Exposure to changing temperatures or undue handling are factors which aggravate surgical shock. Studies of the influence of movement on shock have recently been reported by Miller,¹⁰ who recommends the bringing of the bed to the operating room, a custom practiced in Cushing's clinic for many years.

There is need, therefore, for a clearer differentiation of subdural hematomas into the acute and chronic phases. Selection of patients with acute subdural hematomas who can be benefited by operation is of utmost importance.

ACUTE SUBDURAL HEMATOMA

Acute subdural hematoma is an accompaniment of severe head trauma in which, as a result of injury to cerebral vessels, there has been bleeding into the subdural space. Of and by itself, acute subdural hematoma can hardly be said to exist, for invariably there is associated serious if not extensive laceration of the brain as well as a fracture of the skull. The bleeding is arterial as well as venous. From the injured vessels varying quantities of blood spread through the subdural space and the adjoining subarachnoid meshes. Often a fine layer of blood dissects its way beneath the pia mater.

A brief consideration of the mechanics involved in this type of injury will aid in the better understanding of the relative effects upon the brain and skull following a transmitted blow to the head. Because of the suspended position of the brain, a transmitted injury to the head will cause the brain to travel at a different rate of speed than the skull. At the moment of impact, the skull starts to move ahead of the brain which, because of its inertia, lags behind. The brain, having started to move later, still continues to be propelled after the moving force of the skull has spent itself. It is during this period of shift that the brain, continuing in its course, is pitched against the jagged prominences at the base of the skull with resulting cerebral laceration and vascular rupture. As one would expect, the most frequent sites of damage are at the tips of the temporal and frontal lobes.

Patients with acute traumatic subdural bleeding present a clinical picture varying with the degree of brain laceration and the associated intracranial bleeding. A single and small laceration of the brain is accompanied by moderate bleeding into the subdural and subarachnoid spaces with evidence of pinkish fluid by lumbar puncture. These patients as a rule are immediately unconscious following the injury and within several hours begin to show signs of recovery. Consciousness may return within an hour or twenty-four hours, depending upon the severity of the head injury. Neurological signs are few and inconstant. The best guide to the degree of cerebral trauma is the varying state of the patient's consciousness. Signs of returning consciousness within several hours point to a favorable outcome and are far more reliable guides of the patient's condition than the pulse or blood pressure readings. Increasing stupor and coma after an interval of twenty-four hours usually means extensive brain laceration, cerebral edema, and massive bleeding. The outlook under such circumstances is unfavorable.

Excluding compound and depressed fractures of the skull and extradural bleeding, acute intracranial injuries are best treated medically by absolute rest, by measures combating shock, by moderate dehydration, and by the judicious use of lumbar puncture. That conservative management of acute head injuries is most desirable was very conclusively brought forth by Wortis and Kennedy¹¹ in their study of 1,000 consecutive cases of head injury at Bellevue Hospital. There can be but little doubt that patients with mild cerebral laceration and small quantities of blood in the subdural space will respond best to the medical measures mentioned. Only harm can come to these patients by operative manipulations. Those who have sustained severe brain laceration with resulting extensive subdural collections of blood seldom are helped by operation and the removal of blood from the subdural space rarely alters the course of events. Thus, of the 257 cases that came to autopsy in the series reported by Wortis and Kennedy,¹¹ 96.9 per cent revealed a fracture of the skull and 91.8 per cent showed brain laceration.

There are, however, a few cases, rare to be sure, with moderate laceration of the brain in which recovery might well ensue if the associated acute subdural hematoma is removed. When such patients recover, they are usually left with disabilities depending upon the extent of the brain damage.

Of several hundred cases of acute subdural hematoma that have come under my observation at Bellevue Hospital, there were only four in which operation seemed to offer some hope. With one exception, practically no improvement was noted following the removal of the acute subdural hematoma. The autopsy specimens disclosed such extensive and irreparable brain damage that one could not hope for anything but a fatality. The one patient (Case 3) who fortunately and surprisingly recovered was left with a paresis of the left arm and a left homonymous hemianopsia. The progression of symptoms after an interval of improvement following the trauma and the focal nature of the convulsions were the indications for operative intervention in this patient.

The history and findings in the four operative cases of acute subdural hematoma follow:

CASE REPORTS

CASE 1.—Acute alcoholism, head trauma, stupor upon admission. External evidence of severe injury, bloody spinal fluid. Improvement for one week then return of stupor, left-sided weakness, dilated right pupil. Spinal fluid xanthochromic. Bilateral trephine, bilateral hematoma without capsule formation. Fatality. Autopsy revealed extensive brain laceration.

History: Thomas W., an unidentified man, aged 56 years, was brought to the hospital on Nov. 26, 1935, in a confused and stuporous condition. He evidently had been in a fight while drunk.

SURGERY

Examination: The patient was unable to cooperate. There was a ragged scalp laceration over the left parietal region, ecchymosis about the right eye, clotted blood in both nostrils, and laceration of the lower lip. Except for depressed reflexes, there were no abnormal neurological signs.

Laboratory data: Temperature, 99; pulse, 84; blood pressure, systolic 130, diastolic 74. The spinal fluid was uniformly bloody.

Course: There was very little change in his condition until three days later when he began to show signs of returning consciousness. After three days, he again became stuporous. The right pupil was larger than the left; the neck was stiff; fundi showed no abnormality. A suggestive hemiparesis was present on the left and Babinski sign was positive on both sides. The spinal fluid was xanthochromic and the pressure apparently normal. He was given hypertonic intravenous glucose and caffeine sodium benzoate, but he failed to show any improvement.

Operation: Local novocain anesthesia. Trepanation over the right postparietal region revealed greenish colored dura. When the dura was opened, there was a gush of dark brown fluid. There was no evidence of a membrane. About 30 c.c. of old blood was aspirated, and irrigations with warm normal saline were continued until the returning fluid was clear.

Trepanation then was performed over the left postparietal area. Here also the dura appeared greenish. When the dura was opened, there was no evidence of any membrane. About 15 c.c. of old unclotted blood was aspirated. Irrigations were carried out as on the right side.

Postoperative course: The patient failed to show any signs of improvement. The following morning he died.

Autopsy: The brain showed multiple areas of laceration. The right temporal lobe particularly was markedly softened and contained a large intracerebral clot. (Fig. 1.)

Comment.—With such extensive brain damage, the patient usually is in profound shock and it is not surprising to find very few localizing signs. Our experience has shown that capsule formation seldom takes place where there has been cortical laceration. Operative intervention in this patient seemed advisable for the following reasons: Because following the initial improvement there was a relapse with the appearance of definite localizing signs pointing to the formation of a hematoma. In favor of this conception was also the change in the character of the spinal fluid from a uniformly bloody color to a xanthochromia. It was hoped that the cerebral laceration would be minimal and that the removal of the acute hematoma would permit a satisfactory cerebral compensation. The autopsy findings, however, revealed cerebral lacerations far too extensive for surgical relief.

CASE 2.—Direct head injury with hammer, no loss of consciousness, headache, vomiting, and lethargy for six days. Drift of right arm, Babinski on left, bloody spinal fluid under increased pressure, x-ray of skull negative, progressive right hemiparesis with early papilledema, bilateral trepanation, removal of subdural blood and clots. Immediate improvement. Fatality four days later. Autopsy revealing basilar fracture, subdural hemorrhages, and cerebral edema.

History: Harry B., a 53-year-old janitor, was brought to the hospital on Nov. 5, 1923, because of headaches and drowsiness. Six days before admission, while working in the furnace room, a hammer fell and struck him over the left parietal

region. He was momentarily stunned, fell to the floor, but was able to pick himself up and ascend the stairs. However, he had to be helped into the house. That night and the following day he continued to complain of headache and vomited repeatedly. The headaches persisted; he continued to vomit and gradually became more somnolent.

Examination: The patient was drowsy, but he could be aroused, at which time he was fairly well oriented and complained of generalized headaches. There were abrasions over the left parietal and right occipital regions with adjacent areas of ecchymosis. The pupils were slightly irregular but reacted well to light and accommodation. The fundi showed no abnormality. There was no facial weakness. When both arms were outstretched, there was a drift of the right arm. Response to pinprick was equal on both sides. The deep reflexes were equally sluggish. Babinski sign was present on the left, but doubtful on the right. Blood pressure was systolic 140, diastolic 88.

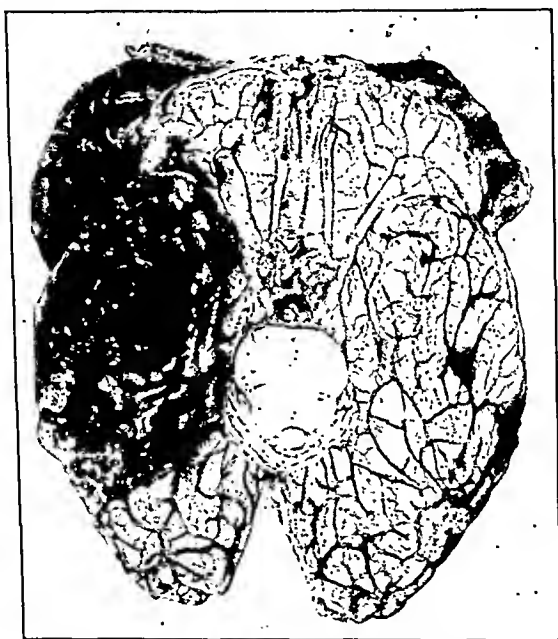


Fig. 1 (Case 1).—Acute subdural hematoma with multiple cerebral lacerations, the most extensive in the right temporal lobe.

Laboratory data: The urine showed no abnormality. Hemoglobin, 88 per cent; red blood cells numbered 4,650,000 per c.mm.; leucocytes were 15,450 per c.mm., with 76 per cent polynuclear forms and 21 per cent lymphocytes; Kline test was negative; blood sugar, 103 mg. per cent; urea nitrogen, 11.2 mg. per cent.

X-ray of the skull gave no evidence of a fracture. The spinal fluid was uniformly bloody, under 330 mm. of pressure. After the removal of 20 c.c., the pressure was reduced to 100 mm.

Course: During three days of observation, the pulse fluctuated between 50 and 60 per minute. At times the patient was alert, at other times he was hard to awaken. Weakness of the right side of the face became evident, the fundi began to show early papilledema, and the right-sided weakness progressed. Spinal fluid was blood tinged under 230 mm. of pressure; after the removal of 10 c.c. of fluid, the pressure was reduced to 100 mm.

Operation: On Nov. 8, 1935, under local novocain anesthesia, a bilateral trepanation was performed over the parietal regions. Through the left trephine hole about 15 c.c. of fresh blood and some clots were removed from beneath the dura. The brain appeared congested and edematous, but no gross blood was found in the subdural space.

Postoperative course: On the following day he was more alert, motion in the right arm and leg improved, the deep reflexes responded well on both sides, but the Babinski sign on the left persisted. Twenty-four hours later he was more drowsy and the right-sided paresis returned. Spinal fluid was xanthochromic, showing a pressure of 420 mm. He gradually became more comatose and died four days after operation.

Autopsy disclosed a fracture of the base of the skull through the left petrous bone, subdural hemorrhages, and marked edema of the left temporal lobe.

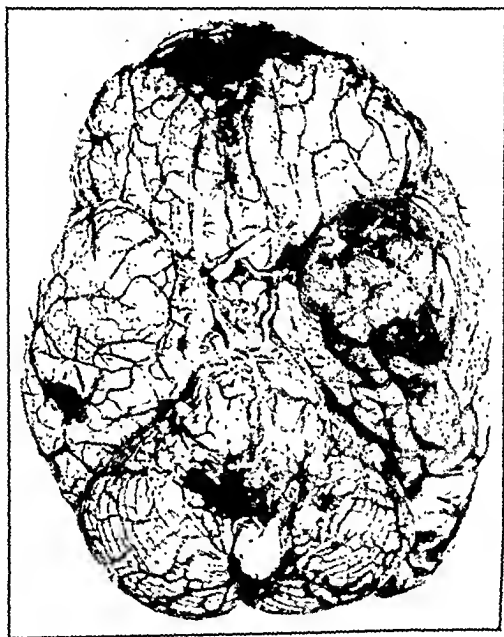


Fig. 2 (Case 2).—Multiple cerebral lacerations most marked at frontal and temporal lobes.

Comment.—Unquestionably the direct blow to the head was much more severe than was suspected upon first examination. The uniformly bloody spinal fluid under such increased pressure pointed to serious intracranial injury. The progressive somnolence and the advancing focal signs over a period of nine days were sufficient indications for operation. However, the autopsy (Figs. 2 and 3) proved that the extensive fracture traversing the left petrous bone, the cerebral hemorrhage, and edema were beyond surgical help.

CASE 3.—Injury to forehead during alcoholic spree. Left-sided convulsions, lethargy, and confusion. Left hemiparesis and hemihypesthesia. Spinal fluid xanthochromic. Bilateral trepanation, acute subdural hematoma on right associated with brain laceration. Recovery with residual spastic paresis of left arm

and left homonymous hemianopsia. Recurrence of left-sided Jacksonian seizures three months later. Encephalograms revealed dilatation and retraction of right lateral ventricle as a result of scarring. Luminal therapy. No seizures for over a year.

History: Mary D., a 49-year-old housewife, was admitted to the hospital in a state of confusion. Seven years previously she had been treated in the psychopathic division for chronic alcoholism.

The patient had been drinking to excess for some time, but one week before admission, while trying to get out of bed, she had bumped her forehead against the dresser. There was no loss of consciousness. Three days later she had a convulsion involving the left arm and left leg. She became drowsy, confused, and was brought to the hospital.

Shortly after admission she had two convulsions. The head and eyes turned to the left, the left side of the face was drawn up, and the left arm and left leg were in tonic spasm.

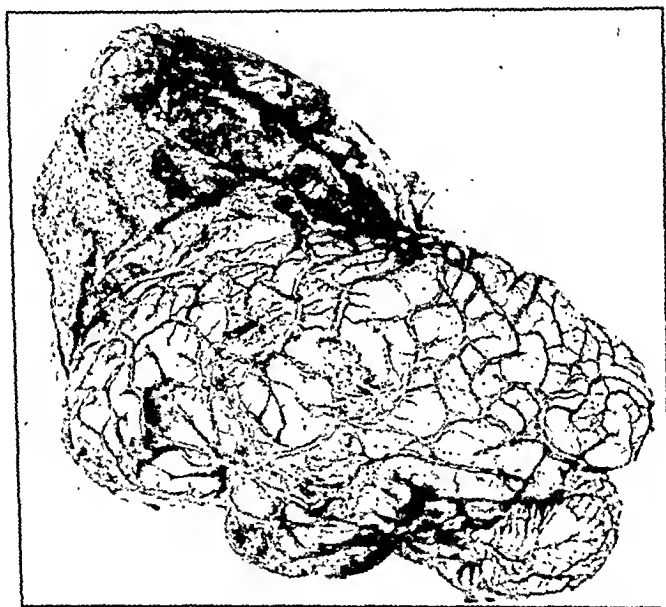


Fig. 3 (Case 2).—Acute subdural hematoma secondary to multiple cerebral lacerations.

Examination: The patient was drowsy but could be aroused sufficiently to state that she had right-sided headache. There were numerous areas of ecchymoses all over her body. The pupils were under the influence of homatropine. The fundi had a frosted appearance, but there was no papilledema. Ocular movements were normal in all directions. There was a distinct left central facial weakness, and the left hemiparesis as well as the left hemihypesthesia involved the arm more than the leg. The deep reflexes were more active on the left, though the ankle jerks could not be obtained on either side. The abdominal responses were absent on both sides. Babinski sign was positive on the left.

Laboratory data: Temperature, 101.4; pulse, 114. Urine showed two plus albumin but was otherwise negative. Blood pressure: systolic, 100; diastolic, 70. Red cells numbered 3,750,000 per c.mm. Leucocytes, 6,100; 75 per cent polynuclear cells, 22 per cent lymphocytes; hemoglobin, 70 per cent; N.P.N., 40. Spinal fluid was xanthochromic. Wassermann was negative.

Operation: On Nov. 8, 1935, under local novocain anesthesia, a bilateral trepanation was performed over the parietal regions. Through the left trephine hole about 15 c.c. of fresh blood and some clots were removed from beneath the dura. The brain appeared congested and edematous, but no gross blood was found in the subdural space.

Postoperative course: On the following day he was more alert, motion in the right arm and leg improved, the deep reflexes responded well on both sides, but the Babinski sign on the left persisted. Twenty-four hours later he was more drowsy and the right-sided paresis returned. Spinal fluid was xanthochromic, showing a pressure of 420 mm. He gradually became more comatose and died four days after operation.

Autopsy disclosed a fracture of the base of the skull through the left petrous bone, subdural hemorrhages, and marked edema of the left temporal lobe.

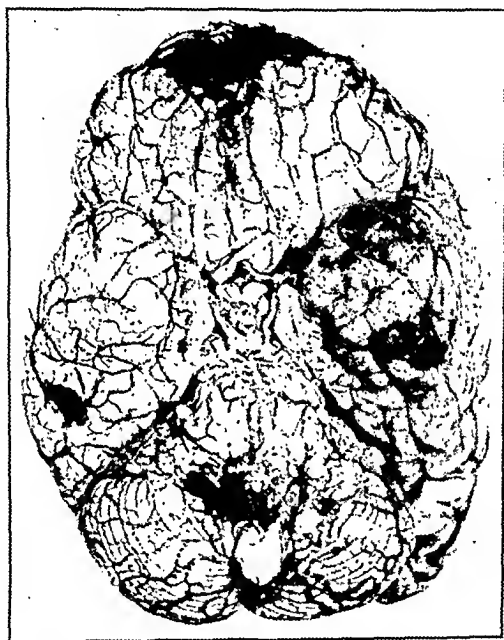


Fig. 2 (Case 2).—Multiple cerebral lacerations most marked at frontal and temporal lobes.

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CASE 3.—Injury to forehead during alcoholic spree. Left-sided convulsions, lethargy, and confusion. Left hemiparesis and hemihypesthesia. Spinal fluid xanthochromic. Bilateral trepanation, acute subdural hematoma on right associated with brain laceration. Recovery with residual spastic paresis of left arm

Second admission: On Feb. 19, 1936, she was readmitted to the hospital because of increasing left-sided Jacksonian seizures. She had been well for two months after leaving the hospital and then noted recurrent twitchings of the left arm and left side of the face.

Examination: The fundi were normal except for moderate retinal sclerosis. Vision O. D. 20/200, O. S. 20/200. The pupils were Argyll Robertson in type. There was a slight left facial weakness, a spastic left hemiparesis particularly involving the left arm, diminished left corneal reflex, overactive deep reflexes on the left, Hoffmann sign on the left, a left hemihypesthesia, and left homonymous hemianopsia. Blood pressure: systolic, 180; diastolic, 108. Blood Wassermann negative.

Encephalograms: On Feb. 28, 1936, after the removal of 110 c.c. of clear spinal fluid, 120 c.c. of oxygen was injected. X-ray films revealed considerable dilatation of the right lateral ventricle with retraction to the right (Fig. 4). The third ventricle was visualized and appeared slightly dilated. The finding suggested cerebral atrophy and scarring.

The patient was put on luminal therapy and has been free from seizures since.

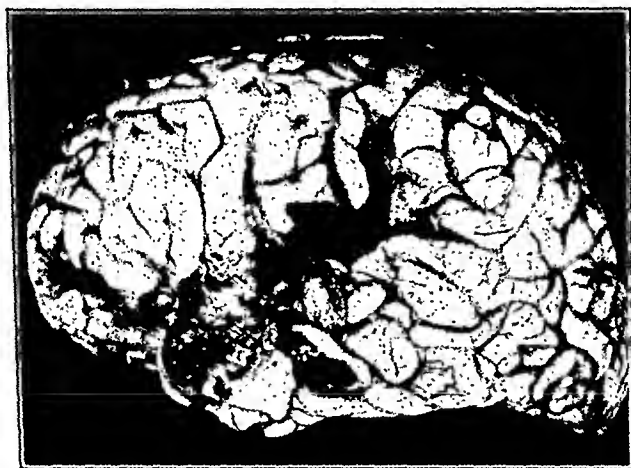


Fig. 5 (Case 4).—Multiple cerebral lacerations associated with acute subdural hematoma.

Comment.—The preoperative diagnosis that there was cerebral cortical laceration in association with subdural bleeding was made because of the history of convulsions and the widespread motor and sensory disturbance. It should be noted that there was no evidence of a capsule. The patient's recovery was unexpected because of the extensive cerebral damage that was found. The residual paresis of the arm was the only incapacity. The encephalographic findings upon her second admission show an interesting late result of cerebral damage.

CASE 4.—Acute head injury, coma, Cheyne-Stokes respiration, generalized convulsion, right hemiparesis, bloody spinal fluid, left-sided convulsion, left hemiparesis. Negative bilateral trephine exploration. Autopsy showed fracture base of skull with extensive cerebral laceration.

Course: After four days of observation, during which period she gradually became more comatose, it seemed imperative that the presence of a subdural hematoma be eliminated.

Operation: Oct. 10, 1935, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The dura on the left appeared normal but when it was incised about 2 c.c. of brownish fluid escaped. The underlying brain appeared congested. The dura on the right was dull gray and under tension and when opened 30 c.c. of dark brown fluid was aspirated. The cranial defect was enlarged to about the size of a half dollar, and with irrigations through a catheter about two ounces of bluish black blood clots were washed out. When the return washings were clear, the exposed brain appeared congested and there were several areas of ecchymoses and laceration. There was no evidence of any capsule.



Fig. 1 (Case 3).—Dilatation and retraction of right ventricle suggestive of cerebral atrophy and scarring.

The sunken brain began to pulsate freely and rise to the surface as more and more of the old blood and clot was removed. During one period of the irrigation, the blood pressure suddenly rose to 200 systolic and within a few minutes returned to the preoperative level of 120 systolic, 90 diastolic.

Postoperative course: The next day she was still drowsy but was taking fluids. The left leg moved more freely, but the left arm remained spastic. Spinal fluid was uniformly pink under extremely low pressure. During the first postoperative week she was given daily lumbar punctures and hypertonic intravenous glucose. She became more alert, motion in the fingers of the left hand began to return, but she had extreme nausea for several days. Her improvement was slow. She was discharged twenty-four days after the operation at which time she was mentally clear, could walk without assistance, but still had weakness and spasticity of the left arm. Visual fields showed an almost complete left homonymous hemianopsia.

Second admission: On Feb. 19, 1936, she was readmitted to the hospital because of increasing left-sided Jacksonian seizures. She had been well for two months after leaving the hospital and then noted recurrent twitchings of the left arm and left side of the face.

Examination: The fundi were normal except for moderate retinal sclerosis. Vision O. D. 20/200, O. S. 20/200. The pupils were Argyll Robertson in type. There was a slight left facial weakness, a spastic left hemiparesis particularly involving the left arm, diminished left corneal reflex, overactive deep reflexes on the left, Hoffmann sign on the left, a left hemihypesthesia, and left homonymous hemianopsia. Blood pressure: systolic, 180; diastolic, 108. Blood Wassermann negative.

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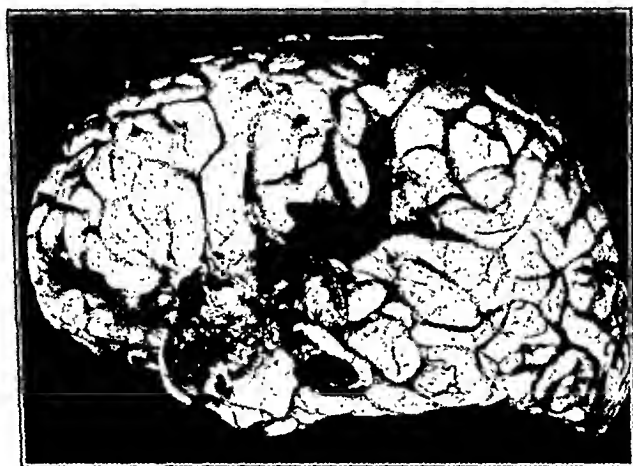


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CASE 4.—Acute head injury, coma, Cheyne-Stokes respiration, generalized convulsion, right hemiparesis, bloody spinal fluid, left-sided convulsion, left hemiparesis. Negative bilateral trephine exploration. Autopsy showed fracture base of skull with extensive cerebral laceration.

History: On Sept. 27, 1936, Robert D., a middle-aged unknown white man was picked up on the street in a comatose condition and brought to the hospital by ambulance. En route he vomited and had a generalized clonic convulsion.

Examination: The patient presented the picture of decerebrate rigidity. Respirations were Cheyne-Stokes in type; pulse was 72 per minute. There was some ecchymosis about the right eye, and further observation disclosed that he had a right facial weakness and a right hemiparesis.

Laboratory data: The urine revealed no abnormality. The spinal fluid was uniformly bloody, under 240 mm. of water pressure.

Course: That evening he had a left-sided convulsion with spasticity and cog-wheel rigidity of the left arm. The deep reflexes on the left were hyperactive and the Babinski sign and ankle clonus were positive on the left. The next day there was spasticity of all the extremities, bilateral positive Babinski, and the spinal fluid was uniformly bloody, under 350 mm. of water pressure. The temperature rose to 105.6 and respirations were 40 per minute. However, within the next two days his condition improved surprisingly. The right pupil became dilated, but the left hemiparesis persisted.

Operation: Sept. 30, 1936, under local novocain anesthesia, a bilateral trephine was performed over both parietal regions. No subdural clot was found on the left. On the right about 25 c.c. of pink fluid escaped from the subdural space.

Postoperative course: During the ensuing week he improved slowly, but then became confused and disoriented. He died twelve days after the trephine exploration.

Autopsy revealed fracture of the base of the skull in the middle fossa, laceration of the under surface of the left temporal lobe (Fig. 5), some blood-stained fluid in the subdural space on both sides, and a bilateral bronchopneumonia.

Comment.—Because he showed signs of improvement during the first three days after admission, it seemed worth while to give him the benefit of a bilateral trephine exploration. The autopsy findings revealed that the cerebral damage was beyond surgical aid.

It is well to realize, therefore, that in the great majority of patients suspected of having an acute subdural hematoma, operation should be withheld. The mild cases will improve under a medical regime. Those severely affected cannot be helped by operative decompression. There are, however, a small number of patients who, after an interval of improvement, begin to show signs of increasing stupor with evidence pointing to a localized collection of blood. Upon these patients operation should be performed.

CHRONIC SUBDURAL HEMATOMA

In a previous publication¹² it was pointed out that chronic subdural hematoma occurs more frequently than middle meningeal hemorrhage. Also, clinical and experimental evidence was presented to prove that a chronic subdural hematoma is the result of a relatively mild trauma to the head which displaces the brain in an anteroposterior direction with a resulting tear of one or more of the cerebral veins as they enter the superior longitudinal sinus. The vein, being least supported as it traverses the subdural space, yields at this point. The venous bleed-

ing that follows into the subdural space is slow, intermittent, and variable and will be influenced by changes in the intracranial tension.

Within ten days to a fortnight, a fine membrane, arising chiefly from the inner lining of the dura, encloses the blood and gradually a cyst wall is formed.

When the intracranial tension falls below the venous pressure, there is a repetition of venous oozing into the cyst until the tension within the cyst wall is sufficient to prevent any further venous bleeding. Headache, vomiting, and lethargy are the most constant symptoms during this phase. As the clot within the cyst retracts and partial organization takes place, the intracranial tension readjusts itself and the patient becomes more alert and at times fully oriented.

The variations in tension within the cyst not only account for the fluctuations in consciousness but also explain the inconstant state of the pupil, the changing paresis, the appearance and disappearance of facial weakness, and Babinski sign. It is not unusual to find the hemiparesis, the dilated pupil, and the chronic subdural hematoma all on the same side.

If one were to make a composite of the clinical stories and findings in this series of fifteen patients with chronic subdural hematoma, it would read as follows:

A middle-aged or elderly individual receives a mild injury to the frontal or occipital region which may be totally forgotten. There is a latent interval from two days to six weeks from the time of injury to the onset of headache. The headache is intermittent and is by far the most constant symptom. Soon lethargy, somnolence, vomiting, mental changes, diplopia, and dizziness follow. Paresis of one side of the body often associated with a dilated pupil on that side may be the only neurological signs in addition to a central facial weakness. The patient becomes gradually more lethargic and then comatose. The symptomatology and findings are often so inconsistent and fluctuate so frequently that one is easily confused. And yet these fluctuations are most characteristic in a patient with a chronic subdural hematoma. These patients are often suspected of a cerebral neoplasm, posttraumatic neurosis, encephalitis, cerebral arteriosclerosis, cerebral thrombosis, and psychoneurosis.

The spinal fluid is usually under increased pressure, and often xanthochromic, but it may be perfectly clear and colorless.

Many a time the only certain and safe procedure to establish the diagnosis is to perform bilateral trepanation.

The history and findings in the fifteen operative cases of chronic subdural hematoma follow.

CASE 5.—No history of head trauma. Headache, diplopia for one month. Period of unconsciousness. Increased spinal fluid pressure and early papilledema. Slight

mental retardation. Inequality of pupils, bilateral external rectus palsy, advancing papilledema, right facial weakness, and bilateral Babinski. Spinal fluid pressure 280 mm. Palsy left side of body under observation. Chronic subdural hematoma over left hemisphere. Removal by craniotomy. Recovery.

History: Fred D., an Italian college student, aged 19 years, entered the hospital on Oct. 1, 1933, complaining of headaches of three weeks' duration. He was perfectly well until one month before admission when he experienced severe frontal headache while drilling in the hot sun in the south. The following morning he was sufficiently well to return to his regular duties, but four days later, during drill, the headache returned and persisted. It was associated with the vomiting of medication on two separate occasions. He was taken to the college infirmary where on the second day he became unconscious and fell out of bed. Upon regaining consciousness he began to have generalized dull headache and then to see double. He also noted numbness of the fingers of the left hand. Because of some stiffness of the neck, a lumbar puncture was done which showed normal fluid under markedly increased pressure, and following this procedure his headache diminished. Vision in the right eye, however, soon began to fail. He noted tingling sensations in the face and both hands and an early papilledema was observed on the right. Lumbar puncture was repeated with complete disappearance of headache, but this had no influence on the advancing papilledema. There was no somnolence, dizzy spells, convulsions, or disturbance of speech. His mental processes seemed to be slightly retarded. He was sent to the hospital with a diagnosis of cerebral neoplasm.

Examination: The patient was an alert cooperative young man who gave a clear and consistent account of his illness. The positive neurological findings were: (1) the right pupil slightly larger than the left, (2) bilateral papilledema, 4 diopters elevation on the left, and 3 diopters elevation on the right, (3) bilateral external rectus paralysis, (4) slight right facial weakness, (5) stiffness of the neck and bilateral Kernig sign, (6) depressed deep reflexes, (7) active abdominal responses, and (8) bilateral Babinski sign.

Laboratory findings: Urine and blood studies were negative. The blood pressure was 136 systolic and 90 diastolic. Cerebrospinal fluid was clear, showed a pressure of 280 mm. with five cells and a negative Wassermann reaction.

Course: Repeated questioning about the fall out of bed did not convince the staff of its etiologic relationship to the illness, and the service was inclined toward the diagnosis of a neoplasm, either of the posterior fossa or in the brain stem.

The patient's condition remained unchanged for ten days. He then began to show weakness of the left leg and the following day weakness of the left arm. In addition there was subjective numbness of these parts but no sensory disturbance could be established. Ventriculograms were undertaken for the purpose of localization and it was during this procedure that a hematoma was disclosed.

Operation: On Oct. 1, 1933, a trephine over the left hemisphere brought to view a grayish dura under moderate tension. When the dura was opened, there was a profuse gush of dark brownish blood, 30 c.c. in all, which spurted with each pulsation of the brain. Upon further investigation some shaggy membrane was removed through the trephine hole which established the diagnosis of chronic subdural hematoma. During this procedure it was noted that the left external rectus paralysis completely disappeared. Knowing the frequency with which this lesion is bilateral, another trephine hole was made over the right hemisphere. The dura and the underlying brain appeared normal.

Two days later the patient's temperature rose. He spat some blood-streaked sputum and for thirteen days was ill with a mild form of bronchopneumonia. The left hemiparesis disappeared within five days after the trephine exploration.

On Nov. 14, 1933, craniotomy was performed and a large flap was turned down on the left side, exposing a well-organized hematoma covering the entire left hemisphere. It was grayish brown, lens shaped, tapering off to meet the arachnoid at the periphery, and firmly adherent to the dura but not to the arachnoid. It was so large that it had to be removed in three pieces (Fig. 6). As one-half of the hematoma was raised, a cortical vein could be seen running into the under surface of the hematoma, probably the source of the venous bleeding. This was clamped and severed.

On the day following the craniotomy there was a mild sensory aphasia, and on the next day he suddenly complained of headache, became more aphasic and drowsy, and developed weakness of the right arm. Several ounces of dark blood were aspirated from beneath the flap resulting in prompt improvement in the above signs. Dakin tubes were left in place for the escape of further bleeding. Several days later he showed evidence of wound infection which was fortunately brought under control.

Upon discharge on Dec. 12, 1933, he was completely well.



Fig. 6 (Case 5).—Extensive chronic subdural hematoma covering almost entire left hemisphere. Removal through craniotomy wound in three portions.

Comment.—Although there is no history of head trauma preceding the onset of symptoms, he may very well have sustained an injury as he fell out of bed. It is surprising that a lesion so extensive should fail to produce aphasia or a hemianopsia. It is also to be noted that the paresis, though mild, was on the same side of the lesion. This patient is the only case in which a craniotomy was performed after drainage through a trephine hole proved unsuccessful. The finding removed by a craniotomy.

CASE 6.—Story of head injury indefinite until after operation. Headaches, dizziness, and somnolence for two weeks. Occasional vomiting and disturbance in gait. Semistuporous state, right facial weakness, left Babinski, spinal fluid lemon yellow tint and under increased pressure. Bilateral trepanation, subdural hematoma on left evacuated. Uneventful recovery.

History: Frank S., a 37-year-old cook, was brought to the hospital in a somnolent condition. The ambulance surgeon obtained an indefinite story from a friend that the patient had had some accident three weeks previously. The details of the accident were not known. For a week after the accident, the patient was able to work, then he began to complain of headache and dizziness. These gradually increased; he became lethargic and vomited on several occasions. He soon found difficulty in walking.

During a period of four days' observation at the hospital, his state of consciousness fluctuated considerably every few hours. When he was more alert, he complained of headache over the right frontal region.

Examination: The patient was semistuporous, would not talk or respond to commands, but could be aroused by painful stimulation. The peripheral vessels showed moderate arteriosclerosis. Blood pressure: 130, systolic; 70, diastolic; pulse, 68 per minute. There was some stiffness of the neck but no Kernig reaction. Pupils were equal, reacted well, and the fundi showed no abnormality. A right facial weakness was questionable. Both arms seemed to have cogwheel rigidity, but there was no paresis. Sensation could not be accurately tested. Babinski sign was positive on the left and occasionally was found on the right. Abdominal responses could not be elicited.

Laboratory data: The urine was negative. Spinal fluid had a slight lemon yellow tint and was under 250 mm. pressure. There were only 3 lymphocytes per c.mm. Total protein 55 mg. per cent.

Operation: Aug. 29, 1936, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura through the right trephine hole was under tension and not discolored. The underlying brain was edematous but otherwise appeared normal.

The dura on the left, however, was slightly bluish. When it was incised, typical dark chocolate colored fluid of a hematoma began to flow. The cranial defect was enlarged to the size of a half dollar. About 180 c.c. of such fluid was obtained from the subdural space. No membrane was seen. Irrigations of warm saline were directed through a catheter to various portions over the left hemisphere until the return washings became clear. The brain was seen sunken about an inch below the surface of the dura. As the fluid escaped from the subdural space, the patient became alert, responded to simple commands, and started to speak. With repeated irrigations the cerebral cortex approached the surface of the dura.

Postoperative course: On the day following the operation the patient was alert, rational, and very cheerful. He volunteered the story that about two and one-half weeks previously he tripped on an orange peel and fell, striking his head against the pavement. He believes he was unconscious for one-half an hour. However, he returned to his quarters where he slept a few hours and then awoke with intense headache. This increased; he felt dull and sleepy, and could not eat. He lost consciousness sixteen days after the injury and was brought to the hospital.

His postoperative course was remarkably smooth. On the seventeenth day after the operation, he was discharged symptom free with no abnormal neurologic findings.

Comment.—A reliable history of head trauma may not be obtained until after the evacuation of a subdural hematoma. In doubtful cases it is far better to explore through a bilateral trephine which, under novocain anesthesia, is simple and not in the least shocking. The regrets have usually been in failing to carry out such a procedure.

The localizing signs indeed were very few and conflicting, in spite of the presence of 180 c.c. of fluid. There were no suggestions of any aphasic components either before or after operation.

The membrane enclosing the subdural fluid must have been so fine that it was not detected at operation, for otherwise the spinal fluid would have shown more than a slight lemon yellow discoloration.

CASE 7.—Trauma to left frontal region. Latent interval six days. Headache and coma of acute onset. Dilated right pupil, right facial weakness, right spastic hemiparesis, clear spinal fluid. Bilateral trephine. Chronic subdural hematoma on right. Uneventful recovery.

History: Charles R., an unemployed lithographer, aged 49 years, was brought to the hospital on April 10, 1934, in a comatose state. The fragmentary history which was volunteered by his landlady seemed to establish the facts that one week before admission the patient received a blow over the left forehead during a brawl. He did not lose consciousness. Six days after the injury he complained of some headache, felt drowsy, and then lapsed into coma.

Examination: The patient was stuporous, but with sufficient stimulation could be slightly aroused, when he would yawn repeatedly. He was incontinent. Fading ecchymosis was observed about the left eye and left temporal region, and the lacerations over the left forehead were completely healed. There were also areas of ecchymosis about the left elbow and left hand. The vessels in the fundi were congested, but there was no papilledema. The pupils were slightly irregular, the right larger than the left.

There was a right facial weakness. Although all the extremities were somewhat rigid, the spastic hemiparesis on the right was very distinct. The deep reflexes were very active, more so on the right. Hoffmann, Gordon, Oppenheim, and Babinski signs were positive on the right. The Babinski sign on the left was doubtful.

Laboratory data: The spinal fluid was clear, colorless, under normal pressure, showing only 9 cells per c.mm.

Preoperative impression: We suspected that this patient had a chronic subdural hematoma on the right, but, because of the injury to the left temporal region, the possibility of an extradural hemorrhage on the left was also considered.

Operation: April 11, 1934, under local novocain anesthesia, a trephine was performed over the right postparietal region. The exposed dura had a greenish tint, and a bluish discoloration could be seen shining through. When the dura was opened, a bluish cystic membrane came to view. This was opened and about 200 c.c. of muddy dark brown fluid was aspirated. Irrigation with warm normal saline was performed in all directions with a No. 14 catheter until the return fluid was clear.

A trephine hole was then made over the left temporal region to rule out an extradural as well as a subdural clot. The dura was normal in appearance, and the underlying brain appeared natural.

By the time the dressing was applied, the patient had regained consciousness, the pupils were equal, the spasticity of the right side of the body had practically disappeared, and the patient carried on an intelligent conversation.

Course: On the second postoperative day he was sitting up reading a newspaper. His convalescence was smooth and without incident. A fortnight after the operation he was discharged, showing no abnormal neurological signs.

Comment.—The dilated pupil, the hemiparesis, the facial weakness, and the Babinski sign were all homolateral with the hematoma. This is not an unusual experience. In fact, it is so often the rule that we

History: Frank S., a 57-year-old cook, was brought to the hospital in a somnolent condition. The ambulance surgeon obtained an indefinite story from a friend that the patient had had some accident three weeks previously. The details of the accident were not known. For a week after the accident, the patient was able to work, then he began to complain of headache and dizziness. These gradually increased; he became lethargic and vomited on several occasions. He soon found difficulty in walking.

During a period of four days' observation at the hospital, his state of consciousness fluctuated considerably every few hours. When he was more alert, he complained of headache over the right frontal region.

Examination: The patient was semistuporous, would not talk or respond to commands, but could be aroused by painful stimulation. The peripheral vessels showed moderate arteriosclerosis. Blood pressure: 130, systolic; 70, diastolic; pulse, 68 per minute. There was some stiffness of the neck but no Kernig reaction. Pupils were equal, reacted well, and the fundi showed no abnormality. A right facial weakness was questionable. Both arms seemed to have cogwheel rigidity, but there was no paresis. Sensation could not be accurately tested. Babinski sign was positive on the left and occasionally was found on the right. Abdominal responses could not be elicited.

Laboratory data: The urine was negative. Spinal fluid had a slight lemon yellow tint and was under 250 mm. pressure. There were only 3 lymphocytes per c.mm. Total protein 55 mg. per cent.

Operation: Aug. 29, 1936, under local novocain anesthesia, bilateral trepanation was performed over both parietal regions. The exposed dura through the right trephine hole was under tension and not discolored. The underlying brain was edematous but otherwise appeared normal.

The dura on the left, however, was slightly bluish. When it was incised, typical dark chocolate colored fluid of a hematoma began to flow. The cranial defect was enlarged to the size of a half dollar. About 180 c.c. of such fluid was obtained from the subdural space. No membrane was seen. Irrigations of warm saline were directed through a catheter to various portions over the left hemisphere until the return washings became clear. The brain was seen sunken about an inch below the surface of the dura. As the fluid escaped from the subdural space, the patient became alert, responded to simple commands, and started to speak. With repeated irrigations the cerebral cortex approached the surface of the dura.

Postoperative course: On the day following the operation the patient was alert, rational, and very cheerful. He volunteered the story that about two and one-half weeks previously he tripped on an orange peel and fell, striking his head against the pavement. He believes he was unconscious for one-half an hour. However, he returned to his quarters where he slept a few hours and then awoke with intense headache. This increased; he felt dull and sleepy, and could not eat. He lost consciousness sixteen days after the injury and was brought to the hospital.

His postoperative course was remarkably smooth. On the seventeenth day after the operation, he was discharged symptom free with no abnormal neurologic findings.

Comment.—A reliable history of head trauma may not be obtained until after the evacuation of a subdural hematoma. In doubtful cases it is far better to explore through a bilateral trephine which, under novocain anesthesia, is simple and not in the least shocking. The regrets have usually been in failing to carry out such a procedure.

from then on steadily improved. Power in the left arm returned. He became fully oriented and spoke very clearly. On the nineteenth postoperative day he was discharged, symptom free, and had no abnormal neurological signs.

Comment.—A trauma to the frontal region, not sufficient to cause unconsciousness, was followed by a latent period of two weeks. Again it was surprising to find such an extensive displacing lesion over the left hemisphere in a right-handed individual without the slightest suggestion of aphasia.

When mental symptoms, fever, stiff neck, and weakness of the left arm became evident one week after operation, it was natural to suspect meningitis or a subdural hematoma on the right which might have been overlooked. The improvement which followed repeated drainage of blood-tinged spinal fluid suggests that cerebral edema and the irritative effects of blood in the subarachnoid space may well account for this temporary, yet surprisingly delayed, complication.

CASE 9.—Indefinite latent interval following head injury. Personality change and delirium. Fluctuating periods of lethargy and alertness. Left-sided paresis and left Babinski. Wassermann positive in the blood, negative in spinal fluid. Bilateral trephine. Chronic subdural hematoma on left. Recovery.

History: On September 7, 1935, William D., a 22-year-old colored porter, was transferred from the psychopathic division because of increasing drowsiness and bilateral papilledema.

There was a history of a primary chancre in 1929 for which he received very little treatment.

He was struck on the head during a street fight. For two days he had a mild headache, but then started to act "queerly" at home. At a nearby hospital a diagnosis of "fractured skull, and C.N.S. lues," was made. After several days he became delirious and was therefore transferred to the psychopathic division. Here his condition changed to one of fluctuating somnolence. There was very little change for ten days.

Examination: The patient was lethargic but at times could be aroused very readily. He had a rigid neck and bilateral Kernig reaction. Several scars of long standing were found over the scalp and face. The pupils were small, equal, and reacted sluggishly to light. Both fundi showed advanced papilledema with tortuous and engorged vessels. No facial asymmetry was noted. Only a mild left hemiparesis was demonstrable. The left knee jerk was more active than the right, and the abdominal responses on the left could not be elicited. Babinski sign was positive only on the left.

Laboratory data: Blood Wassermann reaction was positive. Spinal fluid was xanthochromic and showed a pressure of 500 mm. When the lumbar puncture was repeated two days later, the fluid was clear, the pressure was only 340 mm., showed only S cells, all lymphocytes, total protein was 50 mg. The Wassermann reaction was negative. X-ray films of the skull showed erosion of the posterior clinoids and posterior displacement of the pineal shadow.

Course: The morning following the second lumbar puncture, the patient became alert, responded promptly, and spoke rationally. By 7:00 P.M. that evening he was again in deep stupor and could not be aroused by strong painful stimulation. At 8:45 P.M. he was awake and talking. The following morning he was alert, talkative, cooperative, and facetious. By 1:00 P.M. he was again very drowsy.

have come to rely upon the dilated pupil as a localizing sign in preference to the hemiparesis. Nevertheless a bilateral trepanation is the operation of choice for in about 10 per cent of cases the hematoma is bilateral. In this patient we have a good example that clear spinal fluid, not under increased pressure, is consistent with the presence of a chronic subdural hematoma.

Case 8.—Head injury without loss of consciousness. Latent interval two weeks, under observation, appearance of mental changes, somnolence, dilated left pupil, right spastic paresis. Clear cerebrospinal fluid, coma and fever. Bilateral trepanation. Encapsulated subdural hematoma on left. Meningeal signs and left sided weakness one week after operation. Repeated lumbar puncture followed by complete recovery.

History: Joseph F., a lawyer, aged 47 years, was brought to the hospital on July 6, 1934, in a somnolent state. One month previously he was "held up" and beaten over the left side of the face and forehead, but he did not lose consciousness. In spite of frontal headaches, he managed to attend to business for about two weeks, when it was noted that at times he was disoriented, and soon he began to limp. Shortly thereafter the right arm and right leg became somewhat stiff and weak. Patient was right handed. There were no convulsions or aphasia.

Examination: The patient was very drowsy. When aroused he was confused, disoriented, and uncooperative. There was slight ptosis of the right lid. Left pupil was larger than right. Fundi were normal. Palsy of the right external rectus was slight. There was definite paresis and some spasticity of the right arm and leg. The neck was rigid. Babinski was positive on the right but doubtful on the left.

Laboratory findings: Urine and blood studies were negative. Blood pressure was 145 systolic and 98 diastolic. Cerebrospinal fluid was clear and colorless with only 3 lymphocytes per c.mm.; pressure was 120 mm. Wassermann test was negative.

Course: On the second day following his admission, the temperature rose to 104, pulse was 135, and respirations were 25 per minute. He became more comatose and could not be aroused.

Operation: July 8, 1934, under local novocain anesthesia, a bilateral trepanation was performed over the postparietal regions. When the dura was exposed on the left, it appeared dull gray but had none of the greenish tint usually found. When the dura was opened, there came into view a dark brown shaggy membrane. This membrane was pierced and 150 c.c. of old brownish blood was aspirated. Through a No. 14 catheter irrigation with warm normal saline solution was performed in all directions until the return of fluid was clear. When the hematoma was evacuated, the brain was seen about 3 cm. below the surface of the dura but with repeated irrigation the brain began to pulsate and rise to the surface.

The trephine hole on the right exposed dura normal in appearance. The dura was opened but there was no evidence of a hematoma.

Postoperative course: On the day following the operation, the patient was conscious though irritable and difficult to manage. Temperature, 100.2; pulse, 70; pupils were equal. There was still some spasticity on the right side of the body. His progress was very satisfactory for about a week. When the temperature rose to 104, he became disoriented, his neck became stiff, and some weakness of the left arm was noted. Lumbar puncture was performed and 35 c.c. of blood tinged fluid was removed. His condition improved, lumbar puncture was repeated, and a like quantity of spinal fluid was removed. The fluid was xanthochromic. His condition

from then on steadily improved. Power in the left arm returned. He became fully oriented and spoke very clearly. On the nineteenth postoperative day he was discharged, symptom free, and had no abnormal neurological signs.

Comment.—A trauma to the frontal region, not sufficient to cause unconsciousness, was followed by a latent period of two weeks. Again it was surprising to find such an extensive displacing lesion over the left hemisphere in a right-handed individual without the slightest suggestion of aphasia.

When mental symptoms, fever, stiff neck, and weakness of the left arm became evident one week after operation, it was natural to suspect meningitis or a subdural hematoma on the right which might have been overlooked. The improvement which followed repeated drainage of blood-tinged spinal fluid suggests that cerebral edema and the irritative effects of blood in the subarachnoid space may well account for this temporary, yet surprisingly delayed, complication.

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He was struck on the head during a street fight. For two days he had a mild headache, but then started to act "queerly" at home. At a nearby hospital a diagnosis of "fractured skull, and C.N.S. lues," was made. After several days he became delirious and was therefore transferred to the psychopathic division. Here his condition changed to one of fluctuating somnolence. There was very little change for ten days.

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Opinion: Because of the positive blood Wassermann it was thought for a time that the entire picture might be explained on the basis of meningovascular syphilis. Against this point of view was the negative spinal fluid Wassermann, and the absent pleocytosis in the spinal fluid.

Operation: Sept. 24, 1937, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura on the right did not pulsate but was normal in color. When the dura was opened, the brain was seen to be under increased tension.

The exposed dura through the left trephine hole also failed to pulsate and appeared yellowish. Incision of the dura showed it to be thick and firm, and when it was retracted an encapsulated bluish mass came into view. The capsule was incised and about 60 c.c. of chocolate colored fluid was aspirated. Irrigation was continued in various directions with warm normal saline through a No. 14 catheter until the return washings were clear.

Postoperative course: His improvement started almost immediately following the removal of the hematoma. Before the first week was over, the left-sided paresis and stiffness of the neck had disappeared and the fundi showed subsiding papilledema. A week later he was out of bed and antisyphilitic therapy was started. He was discharged from the hospital four weeks after the operation, at which time he was in excellent condition.

Comment.—The positive blood Wassermann was responsible for the delay in operative intervention. This patient very strikingly portrayed fluctuating periods of consciousness, from deep stupor to alertness and back to a drowsy state, changing within several hours. Careful observations of the state of the pupils unfortunately were not recorded. Perhaps they varied only slightly because of his syphilitic condition. The paresis and the hematoma were on the same side.

CASE 10.—Injury to frontal region without loss of consciousness. Latent interval of a day, then headache, vomiting and personality change. Under observation for a week on psychopathic wards. Stupor and left-sided paresis of rather acute onset. Xanthochromic spinal fluid. Bilateral trephine. Evacuation of subdural hematoma on right. Complete recovery. Sudden death three months later. Autopsy showed no recurrent hematoma and complete absorption of subdural membrane.

History: On Nov. 11, 1935, Michael S., a 76-year-old man, was brought to the psychopathic division of the hospital because of some change in personality.

Three days before admission, while crossing the street, he was struck down by an automobile. He fell on his face and bled from the nose. He did not lose consciousness. Upon arising he felt pain over the right side of the chest, over the right shoulder, and in the left ankle. However, he managed to walk home by himself, a distance of three streets, though he felt weak and somewhat dizzy.

The next day he began to complain of headaches and pain over the lower right chest upon inspiration. For two days he vomited everything taken by mouth. Change in personality as well as some confusion, disorientation, and poor memory were first noted on the day preceding his admission to the psychopathic division of the hospital.

Examination: This 76-year-old man was able to walk into the psychopathic ward although he complained of pain in the left ankle.

General examination showed an elderly man with advanced arteriosclerosis, arcus senilis, and bilateral cataract. Blood pressure: 164, systolic; 80, diastolic. Over the aortic region there was a loud, rough, snapping systolic murmur. In addition

to ecchymosis about the right shoulder there was swelling and tenderness over the left external malleolus. Over the lower right chest anteriorly there was exquisite tenderness.

The positive neurological findings were: (1) stiffness of the neck and bilateral Kernig, (2) pupils, right larger than left, both reacting well to light and accommodation, (3) no papilledema or facial weakness, (4) absent abdominal responses, positive Babinski on right.

Fig. 7.



Fig. 8.



Fig. 7 (Case 10).—Healed curved scalp incision over right postparietal area.
Fig. 8 (Case 10).—Specimen three months after operation. No recurrence of hematoma. Capsule completely absorbed.

Course: Eight days after admission the patient was found in a deeply stuporous condition and incontinent. Examination at this time showed ecchymosis about the right eye, a left facial weakness, a left hemiparesis, absent abdominal responses, and positive Babinski on left.

Spinal fluid was xanthochromic, recording a pressure of 190 mm. After the removal of 5 c.c., it dropped to 110 mm. Following the removal of the fluid, respirations became Cheyne-Stokes in type with period of apnea of distressing duration. He was promptly given 100 c.c. of 50 per cent glucose intravenously and immediately taken to the operating room.

Operation: Under local novocain anesthesia a curved transverse incision was made over the right postparietal region (Fig. 7). A trephine hole brought to view a greenish blue discoloration of the dura under marked tension. Upon opening the dura there was a fine membrane which was easily pierced with the immediate escape of brownish black fluid. The trephine hole was enlarged to about the size of a quarter; a catheter No. 14 size was introduced into the subdural sac and 60 to 70 c.c. of dark brownish fluid was aspirated. Irrigation with warm normal saline was continued until the return flow was perfectly clear. The brain approached the dura, and about this time the patient regained consciousness, started to speak, and began to move the left arm.

In spite of the remarkable change in the patient's condition, trepanation nevertheless was performed over the left postparietal region exposing normal appearing dura, and normal underlying brain. By the time the head dressing was applied, the patient was able to sit up and carry on a clear conversation.

Postoperative course: It was very gratifying on the second day after the operation to hear the patient's clear account of the accident. X-ray of the leg showed an oblique fracture of the left fibula in good position. On the fourth postoperative day he was allowed up in a wheel chair. By the end of the week there were no abnormal neurological signs.

The patient was discharged shortly thereafter with a cast to protect the fractured fibula.

Follow-up note: Three months after discharge, while sitting quietly in his favorite chair, he sent his daughter for some lunch. When she returned, she found him dead. We were fortunate in obtaining an autopsy, which showed advanced coronary sclerosis. The brain (Fig. 8) showed no recurrence of any bleeding. Except for slight staining of the under surface of the dura, there was no trace of any membrane or unusual vascular disturbance.

Comment.—In spite of this patient's age and critical condition there was no hesitation in performing the simple procedure of bilateral trepanation which can be done rapidly and with practically no shock to the patient. A craniotomy might well have tilted the scale against him. The post-mortem specimen offered an unusual opportunity to check upon the final result after a three-month interval.

CASE 11.—Head injury during influence of alcohol. Headache, vomiting, and lethargy. Nystagmus, diplopia, and right external rectus weakness. Advancing papilledema. Blood-tinged spinal fluid under increased pressure. Progression of symptoms under observation. Bilateral trepanation. Subdural hematoma on right evacuated. Recovery.

History: On Jan. 3, 1936, Morris O., a clerk, aged 21 years, was brought to the hospital because of severe headaches for the past two days. On New Year's morning at 3:30 A.M., after having consumed considerable liquor, he fell down some stairs. He was found in a drunken condition at the foot of the stairs with some

blood clots about the nose. The next afternoon, upon awakening, he complained of severe frontal headache, photophobia, and deafness in the left ear. On trying to walk he felt extremely dizzy. He vomited twice. X-ray of the skull suggested a possible fracture of the foramen magnum. It seemed most advisable to have him under hospital observation.

Examination: The boy appeared drowsy and uncomfortable. Over the left temporoparietal region there was an abrasion about 1 inch in diameter. There was some nuchal rigidity but no suboccipital tenderness. The pupils reacted promptly to light and convergence. The fundi showed some blurring of the disk margins. Movements of the right external rectus were limited. The patient stated he saw double upon looking to the right. There was transient horizontal and vertical nystagmus. Hearing on the left was impaired and the left eardrum was reddened.

Laboratory findings: The pulse varied from 60 to 72 per minute. Blood pressure was 145 systolic, 85 diastolic. The spinal fluid was under 320 mm. of water pressure, appeared pinkish, and showed 2,480 red blood cells per c.mm.

Course: Headaches and occasional vomiting continued. After three days the lumbar puncture was repeated; the initial pressure was 200 mm. and showed 510 crenated red blood cells.

The fundi at this time showed progression in papilledema. Withdrawal of spinal fluid or repeated infusions of intravenous glucose brought only slight relief from headache.

One week after admission the spinal fluid showed an initial pressure of 300 mm. There were no cells, but the fluid was xanthochromic. Four days later another lumbar puncture revealed a pressure of 208 mm. There were no cells and the fluid was still xanthochromic.

On Jan. 15, 1936, he complained of some numbness in the left upper extremity but this was not associated with any objective findings. The fundi showed 2 diopters papilledema. The boy appeared more lethargic and his general condition became progressively worse.

Operation: Jan. 16, 1937, trepanation over the left postparietal region disclosed normal appearing dura under tension. The underlying brain appeared injected, but there was no evidence of a hematoma.

When the dura was exposed on the right, it had a greenish-yellow discoloration. Upon opening the dura there promptly came to view a dark brownish encysted mass. This contained over 40 c.c. of dark yellowish brown fluid. In addition there was about one ounce of old clotted blood. Irrigations with warm saline were directed to all parts of the encysted cavity. At first the brain was sunken about one inch below the surface of the dura, but as more and more of the clot was removed, and the washings became clearer, the brain gradually rose to the surface and began to pulsate.

Postoperative course: There was a temporary rise in temperature to 103° on the day following the operation. The next day there was notable improvement; the patient was alert, no longer complained of headache or diplopia. Papilledema began to recede. Lumbar puncture performed five days after operation showed a pressure of 110 mm. with 260 red blood cells per c.mm. On Jan. 30, 1936, the patient was discharged, symptom free with no abnormal neurological findings, except for slight impairment in hearing on the left.

Comment.—From the time of admission, two days after the injury, to the day of operation, some thirteen days later, we had the unusual opportunity of observing the development of a chronic subdural hematoma. Headache and somnolence were the outstanding symptoms.

These steadily progressed and soon diplopia, external rectus weakness, and nystagmus appeared. The spinal fluid changed from being slightly blood tinged to a xanthochromic color, but the pressure was consistently high. To be sure, the capsule of the hematoma was very thin, but yet it was very definite, and its contents showed clotted and liquefied blood.

CASE 12.—Mild head trauma in a hypertensive individual. No loss of consciousness. Progressive headaches, dizziness, and semistupor. Ptosis on right, left hemiparesis, left facial, and left hyperreflexia. Bilateral Babinski. Spinal fluid under increased tension. Ayala index 2.5. Bilateral trephine, subdural hematoma on right evacuated. Fall in blood pressure. Recovery rapid and complete. Hypertension gradually returned.

History: Philip B., a bicycle repair man, aged 58 years, was brought to the hospital in coma. For thirteen years he was known to have had hypertension. At fairly regular intervals he consumed large quantities of liquor.

Ten days before admission, while under the moderate influence of liquor, he slipped and struck the left side of the forehead against an iron bar. There was no loss of consciousness. That night he complained of headache, but the next morning he returned to work and after a few hours the headaches became so severe that he had to go home. During the ensuing week he remained in bed complaining of headaches and dizziness. On the morning of admission he could hardly be aroused.

Examination showed a middle-aged plethoric individual with flushed face and cyanotic lips, lying quietly in a stuporous condition. Painful stimuli only partially aroused him. The neck was stiff and Kernig sign was positive on both sides. There was moderate peripheral arteriosclerosis. Blood pressure: systolic, 210; diastolic, 120. The heart was slightly enlarged to the left.

The pupils were small, irregular but equal and reacted well to light. There was a ptosis of the right upper lid. The fundi showed retinal arteriosclerosis of the hypertensive type. A few medullated nerve fibers were present on the left, but the disk margins showed no elevation. There was a left central facial weakness in association with a left hemiparesis. The knee jerks and biceps responses were more active on the left. The left ankle jerk could not be obtained. Abdominal reflexes were absent. Babinski sign was present on both sides.

Laboratory data: Except for a moderate trace of albumin, the urine was negative; blood sugar, 85 mg. per cent; urea nitrogen, 7 mg. per cent. Spinal fluid was xanthochromic with an initial pressure of 240 mm. After the removal of 10 c.c. of fluid, the pressure reading was 60 mm.; Ayala index, 2.5;* total protein, 74 mg. per cent; sugar, 65 mg. per cent; and chlorides, 60 mg. per cent.

Preoperative considerations: One had to consider whether this man with a known hypertension for thirteen years fell and struck his head as a result of a spontaneous cerebrovascular accident or whether the injury was an independent etiologic factor of a subdural hematoma. The increased spinal fluid pressure and Ayala index pointed in favor of an expanding intracranial lesion. Exploration seemed warranted.

*The Ayala Index is computed by multiplying the ratio between the initial and final spinal fluid pressures by a constant quantity of fluid removed. The quantity of fluid must be 10 c.c. or more. In a recent study of 176 consecutive cases to determine the presence or absence of an expanding intracranial lesion, Savitsky and Kessler¹² found that the Ayala Index was a dependable guide in 84 to 88 per cent. An Ayala Index below 5 favors the diagnosis of a nonexpanding lesion. If the index is above 5.5, it favors the diagnosis of an expanding intracranial lesion. It is a good example of how the Ayala Index aided in the solution of the diagnosis which was made complicated by the factor of hypertension.

$$\frac{\text{Final pressure (60 mm.)}}{\text{Initial pressure (240 mm.)}} \times \text{No. of c.c. of spinal fluid removed (10 c.c.)} = \text{Ayala index (2.5)}$$

Operation: On July 13, 1936, the afternoon of his admission, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura on the left was under moderate tension, did not pulsate, and appeared normal in color. The underlying brain showed no abnormality.

When the dura was exposed through the trephine hole on the right, it appeared light yellowish green. Shining through the dura was a definite bluish discoloration. The bone defect was enlarged to the size of a quarter. When the dura was incised, there immediately came to view "current-jelly clots." A catheter was inserted into the subdural space and by aspiration 35 c.c. of dark brown fluid was obtained. Irrigations with warm saline were directed to all parts of the subdural space until the return washings were clear. While this was being done, the patient became more alert and began to speak. The wound was closed without drainage. The blood pressure in the meantime dropped to 145 systolic, 105 diastolic.

Postoperative course: The following day the patient was alert and even facetious. Motion in the left arm and left leg was improving. The left facial weakness was less distinct.

By the third postoperative day power to the left side of the body returned to almost normal. The facial weakness was only slight. The patient was alert, active, and anxious to get out of bed. Blood pressure: systolic, 174; diastolic, 112. Within the first week after operation, the blood pressure rose to systolic 180, diastolic 120, and at the time of discharge, two weeks after operation, the blood pressure was systolic 196, diastolic 110.

When seen five months after his discharge, he appeared in excellent condition. On one occasion during this interval he had a mild fainting spell at which time he noted tingling of the left hand. From this he recovered promptly. There were no abnormal neurological signs. Blood pressure: systolic, 252; diastolic, 128.

Comment.—In this patient one wondered which came first, the hypertension or the hematoma. In the end it proved that both were present and no doubt were independent.

Also, we have come to rely upon the Ayala index as an indicator of an expanding intracranial lesion. In this patient, particularly, it was put to a crucial test and proved very valuable.

CASE 13.—Headaches and personality change for a year. Severe headache, blurring vision, diplopia one month. Injury two weeks previously, rapid progress of symptoms. Dilated pupil on right, bilateral papilledema, right facial weakness, spasticity both legs, retropulsion, xanthochromic spinal fluid under increased pressure. Ventriculograms showing ventricles displaced to left. Craniotomy. Multilocular chronic subdural hematoma on right in association with meningioma. Immediate recovery excellent. Sudden death. Pulmonary embolism.

History: Sam M., a 50-year-old man, came to the hospital because he repeatedly fell backward when trying to walk forward. For about a year there was a gradual slowing up in his activity and he showed mild changes of personality and memory defects. Two months before admission he began to complain of blurring vision and diplopia. Headaches were rather severe for a month. Two weeks before entry he felt faint and fell; he had to be picked up but managed to get home unescorted. Since then he has fallen several times. When he attempted to walk forward, he fell backward. Dizziness, disorientation, weakness, and urinary retention were the most recent symptoms. There were no convulsions.

Examination showed a man who appeared much older than his age with evident congenital malformations of both hands and right foot. He was alert, cooperative, but child-like in his responses. Blood pressure: systolic, 150; diastolic, 70.

The positive neurological findings were: right pupil larger than left, bilateral papilledema, bilateral external rectus weakness, suggestive right facial weakness, spasticity of both legs, more marked on the left. Gait was with a wide base with marked retropulsion. Babinski sign was doubtful on both sides.

Laboratory data: Urine showed a slight trace of albumin but was otherwise negative. Red blood cells, 4,200,000; hemoglobin, 78 per cent; leucocytes, 7,600 per cubic mm. with 69 per cent neutrophils and 24 per cent lymphocytes. Spinal fluid was xanthochromic under a pressure of 160 mm. of water. After the removal of 10 c.c. of fluid, pressure was 110 mm. Ayala index, 6.9; 2 lymphocytes. Pandy zero, Wassermann negative.

Ventriculography: On July 2, 1936, the patient was suspected of having a right frontal neoplasm. Trepanation was performed over the left postparietal region. The dura appeared under tension. Forty cubic centimeters of clear fluid was obtained from the left ventricle, and 30 c.c. of air was replaced. Roentgenograms of the skull showed marked displacement of both ventricles and interventricular septum to the left. The right lateral ventricle was markedly compressed, the left one was dilated.

Operation: July 6, 1936, a large right frontotemporoparietal craniotomy was performed. The exposed dura surprisingly enough did not appear to be under undue tension. Its color was natural except for a greenish tint in the region of the temporal lobe. As the dura over the right frontal region was incised, there immediately came into view a bluish cystic membrane which was adherent to the under surface of the dura. The dura was gently separated from the membrane and reflected toward the midline, exposing the hematoma which occupied the entire operative field and tapered off toward the tips of the frontal and temporal lobes. Dissection of the hematoma revealed that there were really three different stages of decomposition and organization. In all there was about 2½ ounces of old decomposed blood. Although a direct communication could not be seen between the sacs, yet they were so intimate that differences in osmotic pressures could account for the different characteristics of their contents. The membrane nearest the brain surface was not adherent and peeled off readily except at one point where a large branch of the Sylvian vein was attached to the cyst wall. This might well have been the point of recurrent venous bleeding. The surface of the brain was depressed after the removal of the hematoma, but the convolutions appeared normal. An additional finding was a small meningioma, about the size of a hazel nut, which was attached to the under surface of the dura close to the longitudinal sinus. The tumor was easily removed. At the close of the operation, the patient was given a transfusion of 500 c.c. of blood.

Postoperative course: During the first week after the operation the patient presented the mental picture of a Korsakoff psychosis. He was restless, confused, disoriented, and confabulated. The spinal fluid showed a pressure of 170 mm. of water and the fluid was slightly yellow.

The patient's condition then changed; he became mentally clear and was well oriented. He was able to give an account of his fall. His memory showed signs of improvement. Papilledema began to recede. The wound was healed by primary union and the patient was about ready to sit out of bed when on the tenth post-operative day he complained of feeling weak and promptly died.

Post-mortem examination showed a large pulmonary embolus. The operative site showed no recurrent bleeding.

Comment.—Had it not been for the presence of papilledema, the increased spinal fluid pressure, and the xanthochromia, one could

readily be satisfied in this patient with the diagnosis of chronic encephalitis. The marked ventricular displacement was not in harmony with the insignificant pyramidal tract disturbance and raised the suspicion of a chronic subdural hematoma. The finding of multilocular cysts was surprising. The direct attachment of a vein to the cyst wall has been encountered in a previous craniotomy for a subdural hematoma (Case 5). The possible causal relationship of the small parasagittal meningioma is speculative.

CASE 14.—Mild head trauma to forehead. Headaches, dizziness, unsteady gait, increasing somnolence. Lucid interval three months. Inconstant neurological signs. Encephalogram showing marked ventricular shift to the right. Removal of chronic subdural hematoma through enlarged trephine. Serial x-ray studies of absorption of air from subdural space, and shifting back of ventricles to normal position.

History: On February 15, 1935, Morris D., a 47-year-old man, entered the hospital with the following story. Three months previously he had an attack of "grippe." During this illness he had a spell of dizziness and weakness, felt nauseated, and fainted. As he fainted, he fell and struck the left temporal region against a door. There was no abrasion or period of unconsciousness. Ever since the fall he noted constant pain over the left temporal region. He had frequent periods of nausea but vomited only once. He complained of spells of generalized weakness and compression about the heart. Three weeks before admission he was carefully observed at another hospital where no abnormal findings were discovered. Shortly thereafter the headaches became more severe and radiated to the occipital region and across the right side of the head. He soon became unsteady on his feet, began to see double, and became increasingly somnolent. There was no speech disturbance and no convulsions. The patient was right handed.

Examination: The man appeared drowsy but could be aroused. He was indifferent to his surroundings. Blood pressure: systolic, 110; diastolic, 70. Pulse varied from 46 to 60 per minute. The pupils were equal in size most of the time, but on several occasions the left one was larger. The fundi were within normal limits and there was only a questionable weakness of the right side of the face. He was slightly unsteady in gait and there was ataxia in performing the right finger-to-nose test. The knee jerks on the right were more active than the ones on the left. The abdominal responses on the right could not be obtained. Babinski sign was at times positive on the right and at other times found on the left.

Laboratory data: The urine was negative. Red blood cells numbered 5,200,000 per c.mm.; hemoglobin, 90 per cent; leucocytes, 10,300 with 64 per cent neutrophiles and 25 per cent lymphocytes; blood Wassermann, negative. Spinal fluid was clear and colorless, under pressure of 100 mm. of water, showing only 3 lymphocytes per c.mm. Pandy test was zero; total protein, 30 mg. per cent; Wassermann, negative. X ray films of the skull showed no evidence of increased pressure or other abnormality.

Encephalograms: Six days after admission, because of the fluctuating somnolence and inconstant neurological signs, encephalography was performed; 135 c.c. of clear fluid was removed and 125 c.c. of air replaced. Roentgenograms of the skull (Fig. 9) showed marked displacement of the ventricular system to the right. The left lateral ventricle was distorted and its displacement was most marked anteriorly but also partly downward. The right lateral ventricle was increased in size. The third ventricle was displaced to the right and compressed. The fourth ventricle appeared normal. The subarachnoid markings were absent on the left side of the skull but appeared normal on the right.

Fig. 9.

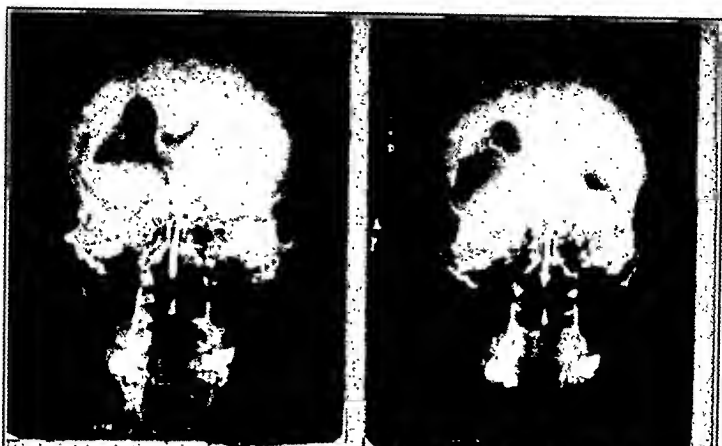


Fig. 10.



Fig. 11.



Fig. 9 (Case 11).—Encephalograms A-P and P-A views. Marked ventricular displacement to the right.

Fig. 10 (Case 11).—Immediate postoperative films showing migration of ventricles to natural position. Air in subdural space outlining the extent of the hematoma.

Fig. 11 (Case 11).—Films one week after operation. Small quantity of air in right ventricle. Absorption of air from subdural sac much slower.

The possibility of a chronic subdural hematoma was strongly considered although a neoplasm could not be definitely ruled out.

Operation: Feb. 23, 1935, a large left temporo-frontoparietal flap was outlined preparatory for a craniotomy. A single trephine hole was first made through a small skin incision over the postparietal region. The exposed dura had the normal shiny luster but was under tension and did not pulsate. When the dura was incised, there came into view the typical bluish membrane of a cyst wall. The cranial defect was enlarged to about the size of a half dollar and the dura then incised in radial fashion. When the cyst wall was punctured, there was an immediate escape of about 120 c.c. of dark brown fluid. Warm saline irrigations through a catheter were then directed to the various limits of the subdural sac. These were continued until the return washings became clear. A portion of the cyst was removed for microscopic study and was subsequently reported as showing organization of a subdural hematoma. The wound was closed without drainage.

Postoperative course: There was prompt improvement in the patient's mental condition. He became more alert, and no longer complained of headache. There was no speech disturbance. Subsequent films of the skull (Fig. 10) showed air in the subdural sac and migration of the ventricles back to their normal position. Repeated x-ray studies (Fig. 11) showed that the air was gradually absorbed in twelve days. He was discharged three weeks after operation, symptom free, and with no abnormal neurological signs.

Follow-up note two years later: Shortly after his discharge he returned to his previous job and has remained active since.

Comment.—Favoring the diagnosis of a chronic subdural hematoma was the history of a mild head trauma as well as the disproportion between the extensive ventricular displacement as shown by encephalography and the few neurological signs. A patient with a neoplasm producing such marked ventricular deformity would most certainly have exhibited an aphasia and a right hemiplegia.

Films taken postoperatively clearly showed the extent of the hematoma, the degree to which the cerebral cortex was compressed, and the return of brain and ventricles to their proper relationship.

CASE 15.—No history of head trauma. Headaches, fatiguability, personality change, somnolence. Cachectic appearance, lethargic periods, bradycardia, left ptosis, right facial weakness, no pyramidal tract signs. Ventriculograms normal. Metastatic neoplasm suspected. Left frontal exploration. Chronic subdural hematoma evacuated. Recovery.

History: Abe B., a 52-year-old glazier, was admitted to the hospital with the complaints of mild generalized headaches, fatigability, and listlessness, all of one month's duration. During this period the family noted a change in personality and a slowing up in mental processes. Shortly before admission he became unsteady on his feet, dragged the right leg, and speech became thick. He became increasingly drowsy. There was no history of trauma. The patient was right handed.

Examination: The patient was in a lethargic condition but could be aroused easily. He appeared very much emaciated. The lips were cyanotic. Blood pressure was systolic 105, diastolic 70. Pulse rate was 51 per minute. His lethargic state alternated with periods of alertness. Speech was thick and unintelligible. There was a drooping of the left upper lid, but the pupils were regular, equal, and reacted

well to light stimulation. The fundi showed slight nasal blurring. A right facial weakness could not be disputed, but there were no other motor or sensory dysfunction that could be demonstrated. At times the deep reflexes on the right were more active than on the left, but this was not constant. The abdominal responses were diminished on the right. Plantar flexion was normal on both sides.

Laboratory data: The urine was negative. Red blood cells numbered 4,400,000 per c.mm.; hemoglobin, 82 per cent; leucocytes, 9,800 with 69 per cent neutrophils and 24 per cent lymphocytes. Spinal fluid was clear, under 90 mm. of water pressure showing only 2 cells per c.mm. Wassermann test was negative. X-ray films of the chest and skull revealed no abnormality. Studies of the gastrointestinal tract failed to show any organic lesion.

Preoperative considerations: Although the few localizing signs pointed to a left frontal lobe lesion, yet the nature of the lesion was not very clear. Several diagnoses were considered: (1) a primary cerebral neoplasm, (2) a metastatic tumor, and (3) a chronic subdural hematoma.

Ventriculograms on July 23, 1936, showed both lateral ventricles well filled, normal in size, shape, and position. The third ventricle was also well visualized and not displaced.

Course: The patient continued to complain of headache, was drowsy most of the time, and showed a persistent bradycardia. Repeated examinations for a primary extracerebral malignancy failed to disclose any lesion.

Operation: Aug. 20, 1936, under avertin and local novocain anesthesia, a left temporofrontal craniotomy was outlined. While joining two trephine holes over the left frontal region, the dura was found unusually adherent to the skull. As it tore at one point, there was a gush of 30 c.c. of old brownish fluid. The dura was then incised through a third trephine hole and a definite membrane with a collection of dark brown subdural fluid could easily be seen. Irrigations with warm saline through a small catheter were directed underneath the trephine holes to various parts of the subdural space until the return washings became clear. The underlying brain approached the surface of the dura, and the wound was closed without drainage.

Postoperative course: Following the operation the patient became more alert but for about a fortnight he continued to show mental changes and speech defects. He was euphoric, confabulated, and at times completely disoriented. These symptoms all cleared so that at the time of his discharge, Sept. 16, 1936, he was in excellent condition and showed no abnormal neurological signs.

Follow-up note: Feb. 2, 1937, the patient was mentally clear, his memory was excellent, he had returned to work as a glazier, and neurological examination was completely normal.

Comment.—About 2 per cent of patients with chronic subdural hematomas fail to give a history of any head injury, and this patient may well be included in that group.

A metastatic lesion seemed very likely because of the patient's cachectic state and the normal appearing ventriculograms, but, since a primary focus could not be established, exploration seemed justifiable. That a chronic subdural hematoma should fail to produce any abnormality of the ventricular system is very unusual. However, within the past year at the Mt. Sinai Hospital two intracranial neoplasms were successfully removed from patients whose ventricular systems were well outlined and showed no displacement or deformity.

CASE 16.—Trauma to frontal region, latent interval of six weeks, headaches, vomiting, and diplopia. Bilateral papilledema, bilateral external rectus palsy. Right facial weakness and right Babinski. Cerebellar neoplasm suspected. Bilateral trephine disclosing a chronic subdural hematoma on left. Removal by suction and irrigation. Recovery.

History: On Dec. 3, 1936, Joseph D., an 8-year-old schoolboy, was admitted to the hospital complaining of headache and double vision.

Three months before admission, while sitting on the running board of an automobile, the machine suddenly started and the boy was pitched forward. The top of his forehead struck the pavement and he was unconscious for ten minutes. The accident was considered a minor incident, for the boy had no complaints and returned to school on the following day.

He was symptom free for six weeks after the accident and then began to complain of frontal headaches and vomited occasionally. For two weeks he had pain



Fig. 12 (Case 16).—Postoperative film of skull showing enlarged left trephine through which hematoma was removed.

in back of the neck. Three days before admission he stated that objects appeared double and at this time his mother noted that the eyes were crossed.

Examination: The boy was alert, cheerful, and cooperative. There was a tendency to posturing the head toward the right. The pupils were dilated; the fundi showed bilateral papilledema with an elevation of 4 to 5 diopters. Bilateral external rectus palsy was present. Nystagmus was slight, inconstant, and more notable upon looking toward the left. A right facial weakness was readily demonstrable. There was generalized hypotonia but no motor weakness. The deep reflexes were sluggish on both sides. The Babinski sign was positive only on the right. There was not the slightest suggestion of any speech disturbance or visual field defect. The patient was right handed.

Preoperative impression: Because of this patient's age, the advanced papilledema, and the few localizing signs, a cerebellar neoplasm was suspected. For this reason

a lumbar puncture and spinal fluid studies were omitted. However, because of the history of trauma, ventriculograms were advised to aid in the differential diagnosis.

Operation: Dec. 7, 1936, under local novocain anesthesia, trepanation was performed over the right postparietal region. The exposed dura was normal in color but under tension. A ventricle needle was then inserted in the direction of the right ventricle, but two different attempts failed to yield any fluid. This was particularly disconcerting for with a cerebellar neoplasm one anticipates finding dilated lateral ventricles. A third attempt in a lateral direction encountered the right lateral ventricle, but only 4 c.c. of fluid could be obtained. It seemed quite evident that the lesion was on the left.

Novocain was then infiltrated over the left postparietal region; a trephine hole was made which exposed a bluish green dura. The bone defect was enlarged to the size of a half dollar (Fig. 12). As the dura was opened, there appeared a grayish red shaggy membrane. When this was opened, about 150 c.c. of old brownish blood was aspirated. Irrigation with warm normal saline was directed to various parts until the return washings were clear. The underlying brain could readily be seen at a depth of 3 cm. below the dura. The brain did not pulsate. Further inspection toward the occipital region disclosed another encysted hematoma which had a thin shiny membrane. When this was opened, about 100 c.c. of old blood escaped. This was not as brownish as the blood obtained upon opening the first capsule. Irrigations were continued as previously. The return washings became clear; soon the brain began to rise to the surface and cerebral pulsations became visible. By this time the child was in moderate shock. An infusion of saline and glucose followed by a transfusion of 200 c.c. of blood promptly improved his condition.

Postoperative course: The next day the right facial weakness became more marked, and in addition there was some weakness of the right arm. Speech was normal. The left external rectus palsy was definitely less. By the end of the first week there was no facial or motor weakness, the papilledema began to recede, and the Babinski sign disappeared. Spinal fluid was clear but under 250 mm. pressure.

At the time of discharge on Jan. 6, 1937, the fundi were normal but the left external palsy was still present. He was symptom free and had no other abnormal neurological sign.

At a recent visit he appeared in excellent condition, the left external palsy had completely disappeared, and he was ready to return to school.

Comment.—Although it is rare to find a chronic subdural hematoma in a child, yet it is even more surprising to find such an extensive collection of blood over the left hemisphere with so few localizing signs. It has been pointed out in a previous publication¹² that the brain accommodates itself to an unusual degree in the presence of the soft sponge-like pressure of encysted blood.

CASE 17.—Injury to forehead eight weeks previously. No loss of consciousness. Headache, weakness, vomiting, and somnolence. Neurological signs few and inconstant. Suspected of psychoneurosis. Xanthochromic spinal fluid. Coma. Bilateral trepanation, aspiration of bilateral chronic subdural hematoma. Postoperative anxiety state. Recovery.

History: On September 13, 1937, Celia K., a 39-year-old housewife, was brought to the hospital because of headaches and weakness. Eight weeks previously she

struck her forehead against an open door. She was dazed but did not lose consciousness. Since the injury she has complained of sharp, throbbing, generalized headache, particularly severe over the frontooccipital regions. Despite several weeks' vacation the headaches persisted; she slept very little and lost weight. On several occasions she vomited rather forcefully and sudden movements of the head brought on a spell of dizziness. For ten days before admission the headaches were so severe that she remained in bed. Memory, speech, and temperament were unchanged.

Examination: The patient lay in bed moaning and whining with headache. General physical examination failed to reveal any abnormality. Blood pressure: 133, systolic; 90, diastolic; pulse, 70 per minute. There was a tendency to keep the right eye closed. Fine tremors of the upper eyelid were observed, but there was no true ptosis. The pupils were equal and responded well to light and accommodation. A left central facial weakness was inconstant. Motor and sensory systems were intact. The deep reflexes were all active and equal. Hoffmann sign was present on the left; the abdominal responses were not consistent. There was no Babinski sign, but stimulation of the left plantar surface failed to produce normal flexion.

Her two children and the home were cause for repeated anxiety. She feared pregnancy, dreaded having another child, and almost completely abstained from sexual relations. With such a background, the vague symptoms and the inconstant neurological signs at first led to the suspicion of a psychoneurotic state.

However, on the day after admission she seemed lethargic, vomited twice, rather forcefully, became confused, and had difficulty in voiding.

Laboratory data: The urine, blood, and x-ray studies of the skull were completely negative. The spinal fluid was xanthochromic under 60 mm. of water pressure, showing 6,000 erythrocytes.

Course: Shortly after the spinal puncture the patient had projectile vomiting. She became more somnolent, the right pupil was notably larger than the left, and by evening she could not be aroused.

Operation: Sept. 15, 1937, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura on the left had a greenish discoloration. The dura was incised and a thick brownish grey membrane came into view. When the membrane was punctured, about 1 ounce of dark brown blood escaped. Through a catheter, irrigations of warm saline were continued in all directions until the return washings became clear. The underlying brain could readily be seen pulsating freely as it approached the surface.

The exposed dura on the right had the normal glistening color and did not pulsate. The opening on this side also exposed a thick brownish membrane. Upon opening the membrane, there was an immediate escape of about 1½ ounces of dark brown blood. Irrigations with warm saline through a catheter were similarly performed on this side until the return washings were clear and the brain approached the surface. The patient regained consciousness before the close of the operation. Both wounds were then closed without drainage.

Postoperative course: The following day the patient was alert, free of headaches, and cooperated well. Within two days the tendency to keep the right eye closed completely disappeared. Spinal fluid was clear, under 20 mm. pressure showing 200 crenated red blood cells. On the third postoperative day she began to manifest signs of anxiety, fearing that another operation was necessary. Neurological examination was completely negative. She was discharged from the hospital on the twelfth postoperative day, at which time she was greatly improved. Her physician reports that, except for moderate anxiety about minor problems, she is perfectly well.

Comment.—The rather vague history and the indefinite neurological signs were strongly in favor of a functional disorder, but the xanthochromic spinal fluid very promptly aroused the suspicion of a chronic subdural hematoma. The vomiting and coma that followed shortly after admission would have made exploration mandatory, even had the spinal fluid been crystal clear. This was the first and long awaited case with a bilateral chronic subdural hematoma in the series. That another might soon follow was realized within a fortnight.

CASE 18.—Trauma to occipital region, diplopia, nausea, vomiting, lethargy and coma, Cheyne-Stokes respiration. Left pupil larger than right and slight ptosis on left. Bilateral Babinski. Spinal fluid clear and colorless, moderate pressure. Bilateral trepanation, aspiration of bilateral chronic subdural hematomas. Recovery.

History: On Oct. 28, 1937, Lena R., a German housewife, aged 69 years, was brought to the hospital in a comatose condition.

Six weeks before admission she skidded on a rug which slipped from under her, fell, and struck the back of the head. There was no loss of consciousness, but she was dazed for about ten minutes and then went about her duties as usual. Intermittent frontooccipital headaches, which were usually worse in the morning, followed. A month later, on several occasions, the patient complained of diplopia. For two days there was nausea and repeated vomiting. On the morning of admission she became drowsy; by afternoon she was stuporous, and that night in a comatose state she was hurried to the hospital.

Examination: The patient was in coma; respirations at times were Cheyne-Stokes in type. Pulse was 72 per minute. Blood pressure: 130, systolic; 80, diastolic. There was no stiffness of the neck. The left pupil was larger than the right, and there was a slight ptosis of the left upper lid. The corneal responses were poor. The fundi were normal except for moderate vascular sclerosis. There were no ocular palsies, and no demonstrable facial weakness, motor or sensory disturbance. The deep reflexes of the upper extremities were active and equal. The knee and ankle jerks could not be elicited. There was no Kernig reaction. Babinski sign was positive on both sides.

Laboratory data: Urine and blood studies revealed no abnormality. The spinal fluid was clear and colorless, with an initial pressure of 150 mm. of water. Microscopically it showed 60 red blood cells per c.mm. Total protein was 29 mg. per cent. After the withdrawal of 10 c.c. of fluid, the pressure reading was 40 mm. Ayala index was 2.6.

Operation: Within two hours after admission, the patient was taken to the operating room where, under local novocain anesthesia, bilateral trepanation over the postparietal regions was performed. The exposed dura on the left did not pulsate but was bluish. Upon opening the dura, a fine membrane was pierced and there escaped 50 to 60 c.c. of dark brown bloody fluid which did not coagulate. The dura on the right was of normal color and showed no pulsations. As the dura was opened, a fine membranous capsule was pierced and there escaped about 100 c.c. of dark brown blood which had the same color and consistency as the hematoma on the left. The fluid did not coagulate. While irrigations with warm saline were directed through a catheter, the patient awoke and began to speak. The irrigations were continued on both sides until the return washings became clear and the compressed brain, which was sunken more than an inch, slowly approached the under surface of the dura. Closure was performed in double layer without drainage.

Postoperative course: The patient made an excellent recovery. The spinal fluid on the third postoperative day was xanthochromic and under 60 mm. pressure. She

was out of bed within a week and was discharged on the tenth postoperative day, symptom free, with no abnormal neurological findings.

Comment.—In a 69-year-old woman many causes of coma come to mind, but with a history of a mild trauma, in spite of the clear spinal fluid, a chronic subdural hematoma could only be excluded by trepanation. The patient was in such a critical state that only a simple swift procedure was all she could have possibly tolerated. This experience dramatically emphasizes the necessity for bilateral exploration when a chronic subdural hematoma is suspected and the ease with which an extensive hematoma can be evacuated through an ordinary trephine hole.

CASE 19.—History unreliable except for falling spells. Patient confused, lethargic, and disoriented. Dilated right pupil. Bilateral papilledema. Babinski on right. Clear spinal fluid under pressure. Bilateral trepanation. Chronic subdural hematoma on right. Recovery.

History: Poy C., a Chinese laundryman, aged 63 years, collapsed in the park and was brought to the hospital by ambulance on Oct. 15, 1937. A reliable history could not be obtained. In addition to language difficulty he persisted in answering "yes" and "no" to all questions. From friends it was learned that for three or four months he had had episodes of falling down in the street. He was incontinent and they tired of caring for him.

Examination showed an elderly Chinese man who appeared undernourished, confused, helpless, lethargic, and mentally deteriorating. There was evidence of peripheral arteriosclerosis and several scars over both tibia. The right pupil was larger than the left; both reacted promptly to light. The fundi showed advanced bilateral papilledema. There was no facial weakness. Although he was unable to stand and had a tendency to fall backwards, there was no evidence of any paresis. The right knee and right ankle jerks were more active than those on the left. The abdominal responses were feeble on both sides. Babinski sign was positive on the right, and the left plantar response was equivocal.

Laboratory data: Temperature, 98; pulse, 80; respirations, 18; blood pressure, 135 systolic and 98 diastolic. The urine and blood Wassermann were negative. Hemoglobin, 92 per cent; red cells numbered 5,080,000 per c.mm.; leucocytes, 8,750 per c.mm., of which 62 per cent were polymuclear cells and 32 per cent lymphocytes; N.P.N., 40 mg. per cent. The spinal fluid was clear, colorless, under 420 mm. water pressure, with 56 cells per c.mm. Total protein, 30 mg. per cent; Pandy test, negative; Wassermann test, negative.

Course: For two weeks after admission there were fluctuating states of lethargy and at times he showed surprising mental clarity. Another spinal puncture showed a pressure of 220 mm. and only 2 cells per c.mm. The fundi, however, showed advancing papilledema. The diagnosis of a left frontal neoplasm involving the corpus callosum was considered as most likely. Because of the story of repeated falls, a chronic subdural hematoma was also suspected.

Operation: On Nov. 3, 1937, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura on the right appeared bluish and failed to pulsate. When the dura was incised, 50 c.c. of greenish brown fluid was aspirated. The bony defect was enlarged to about the size of a half dollar and irrigations with warm normal saline through a No. 14 catheter were directed to the various limits of the subdural sac. The cerebral cortex, which at first was considerably depressed, soon began to approach the dura as the repeated

Comment.—The rather vague history and the indefinite neurological signs were strongly in favor of a functional disorder, but the xanthochromic spinal fluid very promptly aroused the suspicion of a chronic subdural hematoma. The vomiting and coma that followed shortly after admission would have made exploration mandatory, even had the spinal fluid been crystal clear. This was the first and long awaited case with a bilateral chronic subdural hematoma in the series. That another might soon follow was realized within a fortnight.

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Operation: On Nov. 3, 1937, under local novocain anesthesia, bilateral trepanation was performed over both postparietal regions. The exposed dura on the right appeared bluish and failed to pulsate. When the dura was incised, 50 c.c. of greenish brown fluid was aspirated. The bony defect was enlarged to about the size of a half dollar and irrigations with warm normal saline through a No. 14 catheter were directed to the various limits of the subdural sac. The cerebral cortex, which at first was considerably depressed, soon began to approach the dura as the repeated

washings returned clear. Exploration through a trephine hole on the left was negative. The wounds were closed without drainage.

Postoperative course: The patient's recovery was slow but steady. Repeated lumbar punctures showed xanthochromic fluid under increased pressure, but after

TABLE I
OUTSTANDING FEATURES IN 15 CASES OF CHRONIC SUBDURAL HEMATOMA

| | |
|--|----|
| Total number of cases | 15 |
| Male | 13 |
| Female | 2 |
| Age | |
| (a) From 8 yr. to 76 yr. | |
| (b) Average, 45 yr. | |
| (c) Ten above 45 yr. | |
| Hematoma on right | 6 |
| Hematoma on left | 7 |
| Hematoma bilateral | 2 |
| Trauma | |
| (a) To frontal or occipital region in practically all cases | |
| (b) In 13 cases there was no loss of consciousness | |
| In 1 patient consciousness was lost for 10 minutes | |
| In the other, a history of trauma could not be established | |
| Latent interval (period from time of trauma to onset of symptoms) | |
| (a) Present in 9 cases | |
| (b) Varied from 2 days to 6 wk. | |
| Symptoms | |
| Headache | 15 |
| Somnolence | 9 |
| Vomiting | 7 |
| Mental changes | 6 |
| Diplopia | 5 |
| Dizziness | 4 |
| Findings | |
| Facial weakness | 9 |
| Extensor responses | 10 |
| Dilated pupil on side of hematoma | 8 |
| Homolateral paresis | 3 |
| Contralateral paresis | 2 |
| No paresis | 10 |
| Stiff neck | 6 |
| Papilledema | 6 |
| External rectus palsy | 5 |
| Bradycardia | 1 |
| Vascular hypertension | 1 |
| Positive blood Wassermann | 1 |
| Spinal fluid (Studied in 14 cases; lumbar puncture not done in patient suspected of cerebellar neoplasm) | |
| (a) Color | 7 |
| Xanthochromic | 7 |
| Colorless | |
| (b) Pressure | 9 |
| Increased | 5 |
| Normal limits | |
| Operation | |
| Bilateral trephine | 13 |
| Craniotomy | 2 |
| Hematoma capsule | |
| Thick membrane | 9 |
| Thin membrane | 5 |
| Indefinite membrane | 1 |
| Mortality | |
| Recovered | 14 |
| Died (pulmonary embolism 10 days postoperatively) | 1 |

two weeks the spinal fluid became clear and showed no elevation in pressure. The papilledema simultaneously subsided. A mild left hemiparesis, which was first noted with improvement in the patient's mentality, soon cleared up. One month after operation he looked and behaved like an entirely different person. He spoke English fairly well and became a favorite with the other patients. At the time of discharge, Dec. 26, 1937, he was symptom free and there were no abnormal neurological signs.

Comment.—The papilledema and mental changes were in favor of an intracranial neoplasm, the location of which was problematical. The history of repeated falls suggested the possibility of a chronic subdural hematoma. The advantages of bilateral trepanation over the postparietal region are almost self-evident. Such a procedure served not only to locate and permit the evacuation of the hematoma, but, also in the event that a hematoma was not found, it would have provided the means to establish the diagnosis by ventriculography.

A summary of the outstanding features in the fifteen cases of chronic subdural hematoma is noted in Table I.

TABLE II
DIFFERENTIAL DIAGNOSIS OF ACUTE AND CHRONIC SUBDURAL HEMATOMAS

| | ACUTE SUBDURAL HEMATOMA | CHRONIC SUBDURAL HEMATOMA |
|--------------------|---|---|
| Type of trauma | Severe—often followed by unconsciousness | Slight—may be forgotten; direction of blow in antero-posterior diameter; rarely loss of consciousness |
| Fracture of skull | Frequent | Almost never |
| Source of bleeding | Arterial as well as venous Laceration of brain | Only venous bleeding No brain laceration |
| Symptomatology | Onset of symptoms almost immediate Seldom any fluctuation of consciousness | Latent interval characteristic weeks to months Fluctuating periods of consciousness |
| Findings | Coma early; it persists and patient dies or it diminishes and recovery may follow Paresis, pyramidal tract signs on side opposite the lesion Convulsions not unusual Aphasia present with lesions in left hemisphere in right-handed individuals | Coma is late manifestation Paresis, pyramidal tract signs, and dilate pupil often on same side with hematoma Convulsions conspicuously absent in entire series No aphasia in 9 cases of extensive hematomas over left hemisphere in right-handed persons |
| Spinal fluid | Uniformly bloody or pink | Xanthochromic, sometimes clear |

One may well ask: Is chronic subdural hematoma just an advanced condition of an acute subdural hematoma, or is it an entirely distinct and separate clinical entity? What evidence there is to differentiate these two conditions is set forth in Table II.

TREATMENT

Under local novocain anesthesia, bilateral trepanation over both postparietal regions is advocated as the method of choice for the localization and removal of a chronic subdural hematoma. Failure to find the hematoma by this procedure occurred only once in this series of patients. In this unusual instance ventriculograms were performed through the same trephines and they showed no abnormality. Subse-



Fig. 13 (Case 18).—Operative site. Bilateral subdural hematoma.

quent exploration over the left frontal region revealed a small flattened subdural hematoma which was readily evacuated with irrigations, a procedure which resulted in complete recovery.

The findings in this series of cases indicate that blood confined to the subdural space is most likely to accumulate over the postparietal region and to taper off in lens fashion to the frontal, temporal, and occipital lobes as well as toward the longitudinal sinus. As has been pointed out by Horrax and Poppen,¹⁴ the hematoma invariably covers from two-thirds to three-fourths of the entire surface of the hemisphere. The encapsulated blood is thickest over the postparietal region, where the brain is least anchored to the under surface of the dura by traversing vessels and where it yields most readily to the spongelike pressure of the enlarging hematoma.

Incisions of the skin about two inches long are made in a curved oblique direction (Fig. 13) over both postparietal regions. Trepanation is then performed which can be used for a subsequent craniotomy should such become necessary. A greenish discoloration of the dura is a good clue to an underlying chronic subdural hematoma. At times it may be advisable to enlarge the trephine hole and extend the opening of the dura. Through a No. 14 catheter, warm normal saline irrigations are directed to the various limits of the subdural sac. The irrigations are continued until the return washings are clear. Invariably the brain will begin to rise toward the surface of the dura and then start to pulsate. Failure of the brain to behave in this manner usually means that considerable blood clot still remains. It is not necessary to remove the sac of the hematoma, unless the clot is so organized as to prevent expansion of the brain. Under such circumstances a craniotomy is most advisable. This may be done immediately or several days following the trepanation. Two patients required craniotomy following bilateral trephine explorations.

Fleming and Jones,¹⁵ as well as Frazier,⁸ have advocated four trephine holes, two on each side, with through-and-through irrigations. Although McKenzie¹⁶ advocates the removal of the hematoma through a small bone opening by suction, he also advises drainage through a good-sized tube. Such drainage I have not found necessary.

Others, including Munro,⁶ advocate bilateral trepanation over the temporal regions, which in most instances will serve very well for the localization and removal of the subdural hematoma. However, exploration through this region has several disadvantages. One is that the temporal fascia and muscle must be traversed before reaching bone, a procedure which is longer and which is often associated with considerable bleeding. Another is that trepanation over both temporal regions invariably entails separate skin preparations and re-draping, which is not only time-consuming—a serious consideration in these critically ill patients—but which also involves the formidable danger of contamination. The most serious disadvantage of bitemporal exploration is realized when no hematoma is found on either side. One would then wish to perform ventriculograms, which through this region is seldom satisfactory. It is obvious that when the possibility of an intracranial neoplasm is also being considered in the differential diagnosis, a procedure which can rule out the presence of a subdural hematoma and at the same time permit the performance of ventriculograms is highly desirable.

CONCLUSION

1. A differentiation of acute and chronic subdural hematomas can and should be made.

2. Acute subdural hematomas invariably coexist with brain laceration and skull fracture. Operation should be withheld except in selective cases.

3. Chronic subdural hematoma is a separate and distinct clinical entity and not a late manifestation of an acute subdural hematoma. Operation is indicated in practically every case, and the results are excellent.

4. Bilateral trepanation over both postparietal regions is the operation of choice for the removal of the chronic subdural hematoma. With few exceptions the hematoma can be evacuated through an enlarged trephine hole. Drainage of the subdural space is not advocated. In the event of a negative exploration ventriculograms can be performed through the same trephine holes.

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THE EFFECT ON THE BLOOD FLOW OF DECREASING THE LUMEN OF A BLOOD VESSEL*

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THE idea appears to be quite general among surgeons that small decreases in the caliber of blood vessels cause corresponding reductions in the blood flow through the constricted vessels. In our work² with the thermostromuhr we have found that successful measurement of blood flow necessitates the application of units which have internal diameters somewhat less than the external diameters of the blood vessels under investigation. Consequently, the question has repeatedly arisen as to the probable influence of this slight constriction on blood flow through the vessel. If the slight constriction that is produced in measuring the flow of blood does not affect the flow, then the next question is: How much can one constrict a blood vessel without decreasing the flow of blood? A satisfactory answer to this question is of importance to those interested in the use of the thermostromuhr, but it should likewise prove of practical value to the surgeon to know how much a blood vessel may be constricted without decreasing the volume of blood to the region supplied.

It might be interesting to note that one can prove theoretically that, under certain assumed conditions, the radius of a blood vessel has to be reduced to approximately 0.4 mm. before the blood flow through it is reduced one-half. However, an experimental demonstration of the principle on animals is far more convincing. Consequently we are reporting here a series of experiments designed to answer the question as to the degree of constriction necessary to reduce perceptibly the blood flow through a vessel, as well as the effect on blood flow of measured amounts of constriction. In order to obtain more complete data on the problem, three series of experiments have been performed: (1) Constricting units were inserted into an artificial circulatory system. (2) Constricting units were placed in the lumen of the carotid artery of the anesthetized, heparinized dog. (3) Constricting units were applied to the outside wall of the intact carotid artery of the anesthetized dog.

ARTIFICIAL CIRCULATORY SYSTEMS

Two artificial circulatory systems were used. One was a gravity system in which the reservoir was elevated so as to maintain a pressure equivalent to the usual arterial pressure of the dog. In this system capillary tubes were used for maintaining a peripheral resistance. The

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other system made use of a constant volume pump (Dale-Schuster) and a satisfactory mechanism for maintaining peripheral resistance. In both series of experiments the constricting units were inserted directly into the system, so that the thickness of the wall of the blood vessel did not come into consideration. These constricting units were bakelite tubes, 8 mm. long, with uniform bores of different diameters. The outside diameter was approximately the size of the blood vessel. The bore varied from 0.60 mm. to 3 mm. In the gravity system the diameter could be reduced almost 50 per cent without causing more than 20 per cent decrease in blood flow when the original diameter was 3 mm. In those experiments which made use of a pump for maintaining the circulation, a decrease in diameter of 48 per cent caused a decrease in blood flow of only 4.5 per cent when the original diameter was 3 mm. Considered in terms of area of the lumen, the figures obtained in these experiments are more impressive. One can reduce the area as much as 70 per cent when using the pump system before any appreciable reduction in flow takes place (Table I). After the constriction is sufficient to cause an appreciable change in flow, additional constrictions have marked effects. In other words, the reduction in flow is rapid after a certain critical point in the degree of constriction has been reached.

TABLE I

EFFECT ON THE BLOOD FLOW OF INTRODUCING CONSTRICTING UNITS (8 MM. LONG) INTO AN ARTIFICIAL CIRCULATORY SYSTEM AND INTO THE CAROTID ARTERY OF AN ANESTHETIZED, HEPARINIZED DOG (ORIGINAL DIAMETER OF LUMEN IS 3 MM.)

| PER CENT DECREASE IN: | | PER CENT DECREASE IN BLOOD FLOW | | |
|-----------------------|------|---------------------------------|---------------|---------------|
| DIAMETER | AREA | GRAVITY SYSTEM | DALE-SCHUSTER | ANIMAL SYSTEM |
| | | | PUMP SYSTEM | |
| 17 | 30.6 | 2.0 | 0 | 0 |
| 35 | 58.2 | 7.5 | 0 | 5.0 |
| 48 | 72.9 | 17.0 | 4.5 | 18.0 |
| 54 | 79.3 | 30.5 | 20.0 | 24.2 |
| 67 | 89.4 | 58.0 | 49.0 | 44.5 |
| 80 | 96.0 | 88.5 | 79.0 | 71.0 |

CONSTRICTING UNITS INSERTED DIRECTLY INTO LUMEN OF CAROTID ARTERY

In most of the experiments in this series the animal's blood was partially defibrinated and heparin was then added in order to make the blood noncoagulable: About 300 c.c. of blood were removed at one time. This blood was defibrinated, carefully strained through gauze, and returned to the animal intravenously. After the blood was well defibrinated, sufficient heparin was added from time to time throughout the experiment to prevent intravascular clotting. The blood pressure was as those employed in the first series of experiments, and they were eliminated the necessity of estimating the thickness of the wall of the blood vessel. In these experiments it was found that a decrease in diam-

eter of about 50 per cent caused a decrease in flow of about 20 per cent when the original diameter was 3 mm. A decrease in diameter of almost 70 per cent caused, on the average, a decrease in flow of 44.5 per cent for the same original diameter. The length of the constricting units was 8 mm. The blood flow was measured directly (Table I).

CONSTRICTING UNITS APPLIED TO THE OUTSIDE WALL OF THE CAROTID ARTERY

In the experiments in this series the constricting units were 10 mm. long and were cylindrical. The blood vessel could be inserted easily through a small groove at the top of the constricting unit. The external

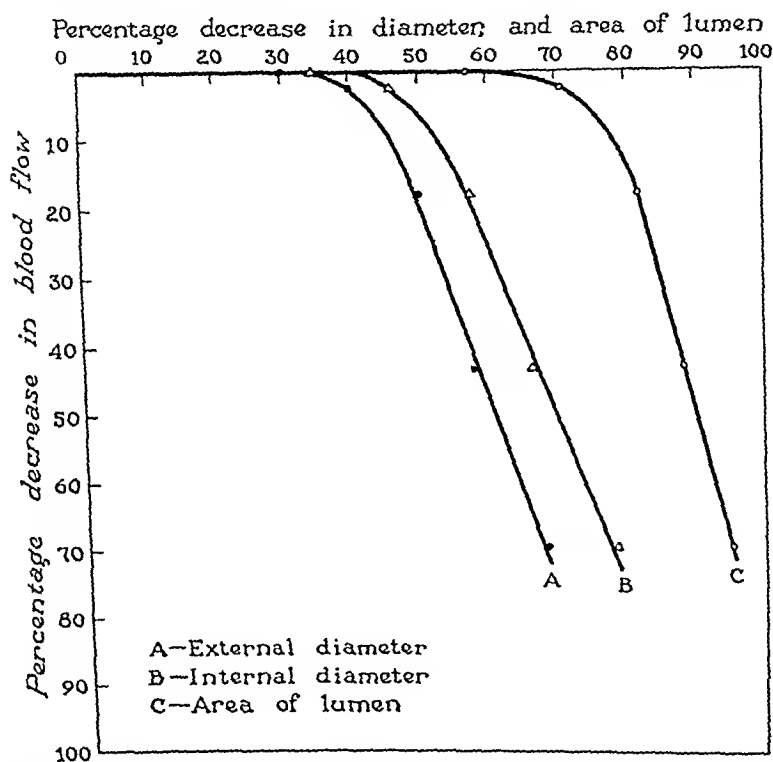


Fig. 1.—The effect on blood flow of decreasing the lumen of a blood vessel: *a*, relation between decrease in external diameter and blood flow; *b*, relation between decrease in internal diameter and blood flow; *c*, relation between decrease in area of lumen and blood flow. The external diameter of the blood vessel was 5 mm.; the double thickness of the vessel, 0.65 mm.

diameter of the blood vessel was measured by a vernier caliper. The vessel was collapsed and the thickness of both walls was measured by means of a micrometer caliper. From these measurements decreases in blood flow could be correlated with external diameter, internal diameter, and area of the lumen of the blood vessel. Four experiments were performed, all of which gave comparable results. The blood flow was measured by the thermostromuhr method. It is interesting to compare the changes in the internal diameter with those of the external diameter. The results appear much more striking if one thinks in terms of the area

of the lumen. Any change less than 10 per cent may be regarded as insignificant (Table II and Fig. 1).

TABLE II

EFFECT ON THE BLOOD FLOW OF DECREASING THE LUMEN OF A BLOOD VESSEL—
EXTERNAL DIAMETER OF BLOOD VESSEL (CAROTID ARTERY), 5 MM.; DOUBLE
THICKNESS OF BLOOD VESSEL WALL, 0.65 MM.

| EXTERNAL DIAMETER | PER CENT DECREASE IN: | | BLOOD FLOW |
|-------------------|-----------------------|------|------------|
| | INTERNAL DIAMETER | AREA | |
| 30.0 | 34.5 | 57.1 | 0 |
| 40.0 | 46.0 | 70.8 | 2.4 |
| 50.0 | 57.5 | 81.9 | 17.8 |
| 57.5 | 66.1 | 88.4 | 43.4 |
| 68.0 | 78.2 | 95.2 | 70.0 |

COMMENT

While accurate measurement of the effect on blood flow of constriction of a blood vessel has been limited to arteries, cursory observations would indicate that the lumen of a vein may also be constricted to a considerable degree without seriously decreasing the amount of blood flowing through it. Some application of the results of this investigation can be made: In relation to our studies on blood flow, it is clearly indicated that a constricting unit can be used which has a diameter smaller than the diameter of the blood vessel. It is also obvious that the lumen at the site of an anastomosis of blood vessels can be less than the lumen of the vessel without seriously interfering with the transport of blood. Finally, it should be noted that success in the repair of injured blood vessels can be anticipated even if it is not possible to restore the lumen completely.

SUMMARY

The carotid artery of a dog may be constricted to a considerable degree before the blood flow is reduced significantly. The results may be given in terms of the reduction in external diameter, internal diameter, or area of lumen. The external diameter of a blood vessel (5 mm. in diameter and with a wall 0.325 mm. thick) may be reduced 40 per cent without a significant reduction in blood flow, but, if the external diameter is reduced 60 per cent, the blood flow is reduced 49 per cent. On the other hand, the internal diameter can be reduced 70 per cent before a 50 per cent reduction in blood flow takes place. The data are most striking when stated in terms of the area of the lumen. The area of the lumen may be reduced 50 per cent without any change in blood flow, and it can be reduced as much as 90 per cent before a 50 per cent reduction in blood flow occurs.

The data were obtained with constricting units of not more than 1 cm. in length.

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REPORT OF 500 BLOOD TRANSFUSIONS

E. H. FELL, M.D., CHICAGO, ILL.

(From the Presbyterian Hospital)

THE early interest in blood transfusions was increased in the seventeenth century following the works of William Harvey. So many severe and fatal reactions followed blood transfusions during this time that the procedure became very unpopular.

In the latter part of the nineteenth century small series of blood transfusions were reported; many reactions occurred, the mortality rate was high. Even though Blundell had shown that small amounts of air introduced into the circulatory system did not produce serious effects, injected air was credited as the cause of reactions. The last decade of this century saw the development of blood vessel surgery and, as a result, transfusions became more common.

Guthrie and Huck in their article "Existence of More Than Four Isoagglutinin Groups" give credit to Samuel G. Shattock, 1899, for the first knowledge of agglutination, which he believed occurred in diseased individuals. Landsteiner, in 1900, is usually given credit for the discovery of isoagglutination, and a year later showed that it was independent of health and disease and followed certain definite laws. His work revealed three blood agglutination groups.

In 1902 V. Decastello and Sturli showed that 4 of 155 patients examined did not come in the Landsteiner grouping. Jansky, in 1907, independently verified this work and stated there were four groups. Two years later Moss, independently, found human blood possessed four isoagglutinin groups.

This knowledge advanced blood transfusion therapy and decreased many of the severe untoward reactions. Severe reactions did occur and many mild reactions. Cross-matching the cells of the donor with those of the recipient was added to the routine grouping, with marked beneficial results.

Various investigators (Landsteiner, Guthrie, and Culbertson) believe that there are other than the four isoagglutinin groups or intragroup isogglutinins. Twenty-seven combinations or groupings, according to Guthrie and Huck, are biologically possible. C. G. Culbertson advises the use of a sensitive centrifuge test in addition to grouping and cross-matching. He found two patients of the intragroup classification who could only be transfused with blood of the same intragroup type. Before adopting this procedure, a patient receiving blood from a supposedly compatible donor (tested by typing and cross-matching) had a severe

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of the lumen. Any change less than 10 per cent may be regarded as insignificant (Table II and Fig. 1).

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greatly increased severe as well as mild reactions. The temperature of the administered fluids must be considered as a cause of reactions.

Two- and three-way syringes used to connect recipient and donor are convenient at times but dangerous. The recipient's blood may be given to the donor. Severe reactions have followed such accidents. A complex apparatus is frequently associated with technical difficulties and hazards.

Incompatibility of blood grouping causes the most severe reactions due to administered blood. It has been shown that there are incompatibilities within the same group. The blood from a donor used twice or more may cause reactions; anaphylactic reactions are reported. The more times a patient is transfused, the more difficult it may become to find a donor, and reactions are more likely to occur.

Toxins contained in administered blood may have been liberated from small clots or traumatized tissue of the donor or recipient. It is felt that toxins are liberated in "preserved" citrated blood and the longer it is preserved the greater the amount of toxins there may be present. Psychic reactions of the donor may give rise to toxins.

The various blood constituents have all, more or less, been attacked as the causes for reactions.

The disease of the recipient has been felt to be the cause of reactions. Some authors do not feel that this is true. It does seem that septic cases are more liable to reactions than others. Moss stated: "No constant differences were found between the agglutinating or hemolysing abilities of sera in health and in disease."

This institution* requires of a professional donor a negative history of malaria, negative Wassermann and Kahn reactions, a compatibility according to the Moss classification, and cross-matching by means of the microscopic slide method. The slide is kept in a moist Petri dish at room temperature for fifteen minutes before examination. These same requirements are made of a nonprofessional donor, except that in an emergency a Wassermann is not done; the Kahn test is always completed. Occasionally a universal donor is used. Recipients are typed and cross-matched before each transfusion when additional transfusions are necessary.

In this group of 500 transfusions, 481 were given by the multiple syringe method, 18 by the citrate method, and 1 by the Seannell method.

Following a transfusion, the apparatus is washed well with cold water, then in soap and water (Ivory soap). It is then rinsed in tap water, dried, wrapped, and sterilized. Immediately before use, the prepared apparatus is rinsed in sterile normal salt solution, then in a sterile 2.5 per cent citrate solution and given to the operator. When transfusing "clean" cases, three 100 c.c. syringes are used; those used twice are rinsed in sterile filtered tap water, rinsed in sterile normal salt solution and in sterile 2.5 per cent citrate solution before the operator receives

*The Presbyterian Hospital, Chicago, Ill.

reaction, chill, temperature of 105° hemoglobinuria, and oliguria. Accurate blood typing and cross-matching are, without a doubt, essential before a transfusion is done.

Reactions following transfusions fall into four main classifications.

I. Severe reactions coming on during or shortly after a transfusion, giving the picture of shock associated with pain in the chest and back, chills, fever, hemoglobinuria, oliguria or anuria, are directly related with incompatibility of donor and recipient blood. The mortality in this group is high. Blood typing and cross-matching of the donor's and recipient's blood have diminished this group to a rarity in well-organized hospitals.

II. Chills and fever may occur within the first twelve hours after transfusion. The mortality is low, but the addition of chills and fever to a sick individual is of negative value. Twenty-four to forty-eight hours after the reaction, the temperature is usually similar to that prior to the transfusion.

III. A temporary rise in temperature of 2 to 3° F. is not uncommon. It returns to its former level in twelve to forty-eight hours following the transfusion.

IV. Urticaria may or may not be associated with fever. It usually is very mild but may be disagreeable for days.

The causes of these reactions concern us all as well as the investigators of the past. A misstep in one direction or another may lead to a disaster. Further investigation and care in giving transfusions should result in fewer reactions.

Causes for reactions as listed by various authors and as observed come under two main headings: (a) technical causes; (b) reactions due to the administered blood.

Technical perfection, adequate equipment, fresh sera, and accurate clerical ability are essential in selecting the right donor and seeing to it that that donor gives the blood to the respective patient.

Lewisohn believes that in his hospital service they reduced transfusion reactions from 12 per cent to 1 per cent by the centralization and efficient attention to the preparation of instruments, apparatus, and solutions used in transfusions. Attention to the preparation of solutions and instruments to be used for intravenous therapy is of prime importance. Emboli and foreign protein or toxic reactions may result from poorly prepared apparatus and solutions. The apparatus must be efficient, the needles sharp and as atraumatic as possible.

The method of administration may be a factor. Individual surgeons not familiar with a technically proper procedure of transfusing are more apt to have reactions than a well-organized team. Too slow withdrawal of blood from the donor may result in clotting; too rapid administration of blood can tax the recipient's vascular system. The administration of "preserved blood," as evidenced by the recent abundant literature, has

Table IV records the two causes of shock found in this series, the number of transfusions given, and their results.

TABLE IV

| | | DEFINITE BENEFIT | TEMPORARY BENEFIT | NO BENEFIT |
|---|----|---------------------|----------------------|---------------|
| 1. Postoperative shock | 34 | 26 | 6 | 2 |
| 2. Post-blood transfusion shock (1 case) | 2 | 2 | — | — |
| | 36 | 28 | 6 | 2 |

The number of transfusions given patients with blood dyscrasias is listed in Table V.

TABLE V

| | |
|--------------------------------|----|
| 1. Agranulocytosis | 8 |
| 2. Myeloid leucemia | 8 |
| 3. Pernicious anemia | 4 |
| 4. Chronic aplastic anemia | 4 |
| 5. Thrombocytopenic purpura | 4 |
| 6. Hemolytic familial jaundice | 2 |
| Total | 30 |

Jaundice is an additional risk to any patient undergoing a surgical procedure and blood transfusions prior and following operations are of benefit. Table VI records the causes of the jaundice and the number of transfusions given.

TABLE VI

| | PRE- AND POSTOPERATIVE | | TOTAL |
|--|------------------------|----|-------|
| 1. Common duct stone | 8 | 7 | 15 |
| 2. Chronic pancreatitis | 1 | 4 | 5 |
| 3. Malignancy with obstruction to bile passages | 3 | 3 | 6 |
| Total | 12 | 14 | 26 |

Table VII presents the number of untoward reactions in its classification.

TABLE VII

| | |
|---------------------------------------|----|
| 1. Chills and fever | 24 |
| 2. Fever only | 22 |
| 3. Urticaria with or without fever | 11 |
| 4. Shock, hemoglobinuria, or oliguria | 1 |
| | 58 |

There were two reactions in this group of 58 reactions which gave definite evidence as to their causes. A brief account of each follows.

The cause of the severe reaction (Table VII, 4) was easily traced to an incompatible donor. The patient had been properly grouped and cross-

them the second time. In case an infectious case is being transfused, no syringe is used more than once and the donor is guarded from contamination.

The transfusions are usually given by the resident surgeon, aided by three interns. Occasionally an attending surgeon is in charge. A few transfusions have been done in the patients' rooms when the risk of moving the patient was of importance; otherwise they were transfused in an operating room.

The indications for the 500 transfusions are listed in Table I.

TABLE I

| | PRE- AND POSTOPERATIVE | | |
|--|------------------------|-----|-----|
| | | | |
| 1. Secondary anemia | 342 | 104 | 79 |
| 2. Directly after prolonged major operations | 66 | | 66 |
| 3. Shock | 36 | | 34 |
| 4. Blood dyscrasias | 30 | | |
| 5. Jaundice | 26 | 12 | 14 |
| | 500 | 116 | 193 |

Table II records the causes of the secondary anemias and their frequency. The transfusions administered to anemic patients due to acute and chronic infections and acute and chronic gastrointestinal hemorrhages are listed.

TABLE II

| | | ACUTE | | CHRONIC |
|---------------------------------------|-----|-------|--|---------|
| | | | | |
| 1. Bladder and prostate pathology* | 95 | | | |
| 2. Pelvic pathology (female)* | 65 | | | |
| 3. Infections | 61 | 38 | | 23 |
| 4. Gastrointestinal hemorrhage | 24 | 21 | | 3 |
| 5. Kidney disease (surgical) | 23 | | | |
| 6. Various causes (requiring surgery) | 22 | | | |
| 7. Pre- and post partum | 15 | | | |
| 8. Malignancy | 15 | | | |
| 9. Nephritis | 6 | | | |
| 10. Trauma | 5 | | | |
| 11. Burns | 5 | | | |
| 12. Nutritional | 5 | | | |
| Total | 342 | | | |

*Benign and malignant.

In Table III the major surgical conditions which were followed directly by a blood transfusion are listed. Transfusions during or following prolonged or shocking major operations are of definite benefit.

TABLE III

| | NUMBER OF CASES |
|-------------------------|-----------------|
| 1. Bowel resections | 31 |
| 2. Stomach surgery | 15 |
| 3. Neurosurgery | 10 |
| 4. Kidney surgery | 6 |
| 5. Gall-bladder surgery | 2 |
| 6. Amputations | 2 |
| Total | 66 |

TABLE IX

| PATIENT | NUMBER OF TRANS- FUSIONS GIVEN | TYPE | METHOD | TYPE OF REACTION FOLLOWING | | |
|---------|--|------|--------------------------------|----------------------------|-------------------------|-------------------------|
| | | | | 1ST TRANS- FUSION | 2ND TRANS- FUSION | 3RD TRANS- FUSION |
| No. 16 | 2 | II | Citrate Multiple syringe | Chills and fever | Urticaria | None |
| No. 29 | 3 | IV | Multiple syringe | Urticaria | None | Temperature, 103° |
| No. 100 | 3 | III | Multiple syringe | Temperature, 101.4° | Chill, 100.4° | Temperature, 100.8° |
| No. 477 | 3 | IV | Multiple syringe | Urticaria | Urticaria | None |

Nine patients received blood from universal donors; 5 were type I, 1 was type II, 3 were type III. Three patients received multiple transfusions from universal donors; 3 received blood from universal donors and donors from their own blood groups; 3 patients received one transfusion, it being from a universal donor. One reaction occurred in this group; it followed the first of four blood transfusions, the patient was a type I.

CONCLUSIONS

The purpose and method of giving 500 blood transfusions to 288 patients are reviewed.

There were 58 untoward reactions encountered; 1 caused by incompatible blood, 1 by technical difficulties, 56 without definite known causes. There was no death due to a blood transfusion.

The severe reactions, as previously described, reawakened the realization that records as to the compatibility of donor and patient must be fool-proof and as simple as possible.

The other 57 reactions indicate that there is much to be done in perfecting our technique of administration and preparation of instruments and solutions before our percentage of reactions (11.6 per cent) is diminished.

There were fewer reactions for each transfusion among the patients receiving multiple transfusions than those receiving one transfusion. The reason for this is not known, but it is felt that the retyping and the rematching of the recipient with donors before each additional transfusion is done is important in lowering the number of reactions in patients receiving more than one transfusion.

The number of patients receiving blood from universal donors in this group of 500 cases is small, but it did not indicate more frequent or severe reactions.

matched with a compatible nonprofessional donor. A laboratory sheet with a list of the compatible and incompatible donors was placed in the patient's chart. The intern, by mistake, called the incompatible donor. The patient went into shock following the administration of 360 c.c. whole blood given by the multiple syringe method. Adrenalin and papaverine were given. The temperature rose to 105.6° F.; hemoglobinuria and oliguria developed. The next day, 500 c.c. of compatible blood were given with no harmful reaction. Nausea and vomiting prevented the oral administration of fluids; fluids were administered by other routes. A third transfusion of 500 c.c. of blood was administered nine days after the first; there was no harmful reaction. The patient recovered.

Within one-half hour of an unsuccessful attempt to give a transfusion by the Seannell method, a patient experienced chills and fever. Considerable time was consumed in giving 40 c.c. of blood. Difficulty was experienced in the venepuncture of the donor and withdrawal of blood. The donor was later used and no reaction followed. The cause or causes for this reaction may be any or all of those listed under technical causes except that which has to do with compatibility.

There is no definite knowledge as to the causes of 56 unfavorable reactions.

The 500 blood transfusions were given to 288 patients. There were 115 patients given more than one transfusion; 30 of the 58 reactions occurred in this group. Ten per cent more reactions occurred to the 115 patients receiving multiple transfusions than to the 173 who received only one transfusion. There were, however, 327 transfusions given the 115 patients, or 9.14 per cent had reactions. The group receiving one transfusion had 28 reactions, or 16.18 per cent reactions. Why such a difference in these two groups exists is not known. Accurate retyping and cross-matching before each additional transfusion no doubt prevent many reactions.

Twenty-one patients had one reaction following one of a number of transfusions. Table VIII lists the 21 cases as to the occurrence of their reactions, following the first, any between the first and last, and following the last transfusion.

TABLE VIII

| | AFTER FIRST TRANSFUSION | AFTER ANY OTHER TRANSFUSION | AFTER LAST TRANSFUSION |
|---|----------------------------|--------------------------------|---------------------------|
| Patients given multiple transfusions with one reaction | 8 | 8 | 5 |

Four patients having received more than one transfusion had, respectively, more than one reaction. Table IX records the reactions in relation to each transfusion.

BLOOD TRANSFUSION AND THE STORAGE OF BLOOD FOR EMERGENCY PROCEDURES

EDWARD B. TUOHY, M.D., M.S. (ANES.), ROCHESTER, MINN.

(From the Section on Anesthesia, the Mayo Clinic)

IT IS authentically reported that in 1667 Jean Denys and Emmerez performed blood transfusion; the recipient was a young man and the donor, a sheep from which $\frac{1}{2}$ pint (250 c.c.) of blood was taken from the carotid artery. The previous epochal work of Harvey on the circulation of blood, in 1616, and the experiments of Lower, in 1665, dealing with transfusion of blood of dogs made possible the first transfusion in which man was the recipient. Blood transfusion has been practiced periodically since 1667 and has enjoyed either favor or disfavor among physicians, depending on the success or failure of the procedure. It was in 1900 that Landsteiner showed that the reason for dangerous or fatal reactions from transfusion were attributable to incompatibilities between serum and cells of donors and recipients respectively. He proved that it is possible for the serum of one normal human being to agglutinate or hemolyze the blood cells of another individual and, further, that a donor's serum may agglutinate the recipient's cells, but the recipient's serum must not agglutinate the donor's cells.

In 1907 Jansky proved that there are four blood groups applicable to human beings and this work was later confirmed by Moss and Ottenberg. The so-called Landsteiner Groups O, A, B, and AB are also known as Groups 4, 2, 3, and 1 respectively according to the Moss classification. The latter grouping is probably the most widely used today, but it is not uncommon to utilize both systems for purposes of accuracy and to list the groups as follows: 1 (AB), 2 (A), 3 (B), and 4 (O). With the latter classification one has a double check on the group of the prospective donor's or recipient's blood, and it should not be possible to confuse the Moss and Jansky systems of nomenclature. Group 4 (O) is the type of blood obtainable from that person who is known as the "universal donor," and Group 1 (AB) is the type of blood which is compatible with all the other groups, and is therefore recognized as blood of the "universal recipient."

There is considerable variation of opinion regarding the practice of using a universal donor, Group 4 (O), for any and all transfusions. It is held by some workers that Group 4 (O) blood should be used only in case of extreme emergency or when recipients of Group 4 (O) require transfusion, and that whenever possible blood of recipients and donors should be of the same group. This opinion is probably one of the

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There is considerable variation of opinion regarding the practice of using a universal donor, Group 4 (O), for any and all transfusions. It is held by some workers that Group 4 (O) blood should be used only in case of extreme emergency or when recipients of Group 4 (O) require transfusion, and that whenever possible blood of recipients and donors should be of the same group. This opinion is probably one of the

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fibrinolysis can be accelerated by heating or shaking, but the mechanism is not entirely understood, since blood collected from individuals who have expired from such wasting diseases as tuberculosis, carcinoma, and so forth, does not exhibit this phenomenon and when this blood coagulates it does not again become liquid.

When the physical and chemical properties of blood of cadavers are evaluated, it is easier to understand why fresh blood obtained from living persons, in the presence of an anticoagulant, can be stored satisfactorily for purposes of transfusion.

An icebox or refrigerator of reasonable size, of which the temperature can be controlled so as to prevent freezing, is satisfactory for storing of blood. The optimal temperature is about 40° F. Refrigerated blood, three weeks old, has been administered to patients without untoward results, but the optimal time for the utilization of stored blood is two weeks or less after the blood has been put in storage. If a bottle of stored blood gives any evidence (grossly) of hemolysis, it should be discarded.

SELECTION OF DONORS

Blood of all professional donors should be carefully grouped. Also, it should be tested by at least one of the accepted procedures to detect positive or negative evidence of syphilis; in many hospitals and clinics it is customary to perform several flocculation or precipitin tests for this purpose. Tests for syphilis should be made at least every six months. Some of the most commonly used tests are the following: the Kolmer modification of the Wassermann test and the Kahn, Kline, and Hinton tests. In addition, every six months to a year, the donors should be subjected to a general physical examination which should include leucocyte and erythrocyte counts, determination of hemoglobin, and urinalysis. Donors whose veins are of large or medium size are preferred and in emergencies only those donors who have excellent veins are called. Professional donors may be used every four to six weeks, if needed, but every six to eight weeks is to be preferred. Each time the donor is called for transfusion he should be required to present a card on which are listed such data as the result of the Wassermann test, the donor's blood group, a certification of physical fitness, and the donor's signature. Some record also must be available to show when a certain donor was last used.

Nonprofessional donors may be friends or relatives of patients or good Samaritans who wish to donate their own blood. In order to determine the suitability for transfusion of blood of individuals of this class, the blood may be grouped according to the Moss or Jansky classification or, if necessary, the short method of cross agglutination may be employed. Serologic tests should be made whenever possible.

soundest, because the supply of universal donors, Group \pm (O), is easily depleted if they are used routinely. Furthermore, the incidence of untoward reactions will be decreased in a large series of transfusions if recipients are given blood of homologous groups. Other factors, such as the method of transfusion, whether direct or indirect, and the agent used to prevent coagulation, likewise will influence the number of reactions to transfusion.

On account of the flexibility of the indirect (citrate or other anticoagulant) method of transfusion, it is usually preferred to the direct method. The relative incidence of reactions when the direct method is used is slightly less than when indirect methods are used, but the practicability of the direct method is not sufficient to warrant its routine use when a large number of transfusions are performed. Furthermore, many recipients object to the intimacy of direct transfusion and will not submit to that method. Likewise, now that the storing of blood is rapidly becoming an important feature in transfusion, the direct method is less attractive than it was.

STORING OF FRESH BLOOD

The work done on blood of cadavers^{17, 20, 21} is the basis on which storage of fresh blood has been developed. It has been shown experimentally that when blood of cadavers, kept at 17 to 20° C., is substituted for as much as 60 per cent to 90 per cent of the total blood of an animal, no serious reactions occur. Stored blood of cadavers does not appear to be of increased toxicity, provided the blood is obtained prior to ten hours after death and provided it is kept cool. For transfusion, the vitality of blood of cadavers, if treated in this way, is unchanged, as is evidenced by the fact that the leucocytes within it have phagocytic power, the hemoglobin and number of erythrocytes of the blood of the recipient are increased, the serum of the blood of the cadavers behaves in the same manner as blood obtained from living persons in respect to fixation of complement, and the blood of cadavers can participate actively in the exchange of gases, one of the important and main functions of blood. Although blood of cadavers has not been used at the Mayo Clinic, such blood, obtained within ten hours after death, has been successfully used in Europe for transfusion when stored for as long as three weeks at a temperature of 17 to 20° C. There are differences, however, in the behavior of blood of cadavers and fresh blood taken from living persons in respect to coagulation; namely, blood from living persons will clot unless it is mixed with an anticoagulant; whereas, blood of cadavers, if the individuals have died suddenly from gunshot, acute trauma, apoplexy, coronary disease, or electric shock, will form a coagulum at first, but, after fifteen minutes to an hour, the coagulum dissolves and the blood becomes liquid once more. This phenomenon of

of large caliber, the size of which depends on the size of the vein, is attached to a rubber tube, 15 inches (38 cm.) long and of relatively small lumen, and the needle is inserted into the vein. A 13 gauge Lewisohn needle is recommended for the larger veins, and a 15 gauge needle for veins of medium size^{9, 11} (Fig. 1). Too much emphasis cannot be laid on the importance of using phlebotomy needles of adequate size and rubber tubing of which the lumen is of proper size, because most difficulties which arise in withdrawal of blood are owing to the fact that small needles are introduced into the vein and the inside diameter of the tubing which leads to the bottle that is to hold the blood is either too large or too small; under such circumstances the blood frequently clots. The tubing should be made of pure para rubber and the inside diameter of the tubing should approximate the diameter of the hub of the needle as closely as possible. Except very occasionally,

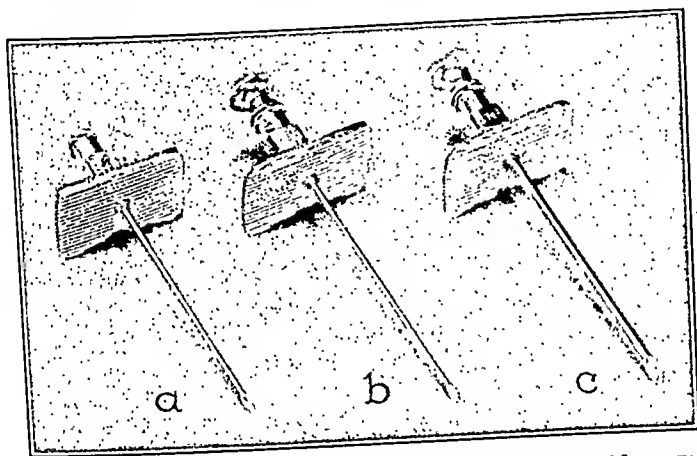


Fig. 1.—a, eighteen gauge Lewisohn needle with stylet removed; b, 18 gauge Lewisohn needle with stylet in place; c, 13 gauge Lewisohn needle with stylet in place.

for instance as in phlebotomy for polycythemia vera, it should not be necessary to use suction appliances to hasten the flow of blood. The donor should alternately open and close his hand while blood is being withdrawn to hasten the flow.

It is purely a matter of preference whether the point of the needle is introduced into the vein with or against the flow of venous blood.¹⁰ Either method is satisfactory and useful.

The blood is collected in a graduated glass bottle (Fig. 2) of a capacity of 500 c.c., into which has been poured 50 c.c. of physiologic saline solution containing 18 gr. (1.16 gm.) of sodium citrate. For convenience, ampules are obtainable which contain 1.16 gm. of sodium citrate in a solution made up to 5 c.c. As an added precaution against clotting when withdrawing blood from polycythemic patients, two ampules of sodium citrate (36 gr. or 2.33 gm.) are added to 50 c.c. of physiologic saline solution.

BLOOD DONOR AGENCIES

Two general methods can be employed in order to supply blood to patients who are in need of transfusion.^{6, 10} Either fresh blood or stored blood can be used. When fresh blood is requested, a donor can be called through some central agency, which will direct him to the hospital or other place where the transfusion is to be performed. Many hospitals have solved this problem of obtaining blood for transfusion by establishing their own lists of suitable donors. The physicians' exchange in most cities would be an excellent bureau to assist in calling and directing suitable donors to the place of operation. A minor point, but still an important one, is that all professional donors should have telephones in their homes so that delays will be minimal. All registered donors should be supervised closely and the organization responsible for obtaining donors should maintain rigid standards in regard to periodic physical examination.

It is equally advantageous for hospitals, especially, to organize emergency laboratories so that blood from both professional and nonprofessional donors may be available for immediate use. Having stored blood on hand will expedite tremendously the average transfusion. It is not absolutely necessary to have on hand blood of all types, but there should be a reasonable supply, 1 to 2 liters, of Group 4 (O) blood, so that the patient who is in need of a transfusion can receive blood without waiting for a donor of his own group to be found or for cross matching to be performed. By the law of averages, blood of either Group 4 (O) or 2 (A) will be most prevalent and blood of either of these two groups will be available most of the time. Prior to administration of stored blood, the bottle, with its contents, should be warmed to body temperature by means of a water bath.

The problem of remuneration for professional donors is legion, and no standard regulations are possible. By and large, the average cost of blood will vary between \$5.00 and \$10.00 per 100 c.c. The average amount of blood taken from one donor at a time is 500 c.c. to 750 c.c. If more than this amount is required, two donors, or more, should be called.

TECHNIQUE OF WITHDRAWING BLOOD (PHLEBOTOMY)

Before withdrawing any blood from the donor, both arms should be examined to determine which vein is most suitable for phlebotomy. As was mentioned previously, only those people whose veins are of medium to large size should be used as professional donors.

After the vein to be used has been selected, the skin over the site of puncture is surgically prepared and anesthetized. In most instances the veins about the antecubital fossa are best adapted for phlebotomy. With 1 per cent solution of procaine, a wheal is raised on the skin over the vein and a tourniquet is applied above the site of puncture. A needle

intravenous therapy and will obviate the difficulties of venipuncture in the event of sudden circulatory collapse. If necessary, the stylet is removed, the needle and vein are irrigated with a small quantity of physiologic saline solution, and then blood, solution of acacia, or any other desired solution is administered. It is worth while to remember that solution of acacia should not be administered either before or after administration of blood, without first irrigating the tubing, since the acacia may cause clotting of the blood in the tubing or needle, or even in the vein.



Fig. 3.—Half-liter bottle inverted, vacodrip adapter, and rubber tubing, with adapter to fit needle.

REACTIONS TO INDIRECT TRANSFUSION

Several factors influence the incidence and number of reactions to transfusion, among which are the following: the rate of administration, the anticoagulant used, the temperature of the blood, the presence of allergic antigens, the quantity of blood administered, and so forth.

The free end of the rubber tubing is held in one hand and the bottle is gently oscillated to insure thorough mixing of the anticoagulant with the blood. Stirring rods are not used. The bottles in which the blood is collected are capped with rubber stoppers and metal collars are screwed securely on the necks of the bottles, holding the rubber stoppers in place. There are two holes in each rubber stopper, one to allow a glass "breather" tube to extend three-quarters of the way toward the bottom of the bottle, and the other to permit a glass vacodrip adapter to be inserted when blood is administered; this latter device makes it possible to utilize the vacuum principle on which the bottle* is designed (Fig. 3).



Fig. 2.—Half-liter bottle for the collecting, storing, and dispensing of blood.

ADMINISTRATION OF BLOOD

When the blood is administered to the recipient, utilization of the same bottle in which the blood was collected saves considerable time and material. The recipient's arm is prepared in the same manner as the donor's was prepared, provided the veins in the arm are suitable for venipuncture; otherwise, other veins are utilized. A needle of small bore, usually 18 or 20 gauge, is inserted into the vein and, when it is certain that the vein has been entered satisfactorily, the rubber tubing from the vacodrip bottle is connected to the hub of the intravenous needle. A maximal rate for administration of blood is 15 c.c. per minute.

In the course of many serious operations it may be found advantageous to insert into a vein a needle fitted with a stylet (Fig. 1), and to anchor the needle securely with adhesive plaster. This maneuver will facilitate

*Bottles adapted from a commercial product, Vacollter.

may be given pentobarbital sodium prior to transfusion with definite advantages. Further suggestions to facilitate venipuncture have been published elsewhere.¹⁰

The indications for blood transfusion are many, but some of the most common indications are the presence of one or more of the following: (1) shock owing to loss of circulating blood, (2) hemorrhagic diseases and blood dyscrasias, (3) debility with or without secondary anemia. Transfusions of from 1,000 c.c. to 5,000 c.c. of blood are not uncommon and are particularly indicated in shock owing to loss of blood and tissue fluid. When such large amounts of blood are administered, it is best to insert into the vein a needle which has a stylet. Then the slow drip of blood can be stopped for periods of one-half hour and the stylet can be inserted and left in place until it is desired to resume the transfusion. By this method the same needle and vein can be used for two or three days. Sometimes gold-plated needles are used for such prolonged transfusions because there is less tissue reaction at the site of venipuncture. Immunotransfusions are being used more extensively than before in cases of anterior poliomyelitis, measles, scarlet fever, and various forms of septicemia, but, as yet, there is no volume of evidence to make the procedure standardized. In certain cases, however, immunotransfusions have been remarkably helpful.

Another source of blood which I have not mentioned, but which ultimately may be used extensively, is the placenta. The method has been described by Goodall and others and by Griffith. Briefly the technique is as follows: After delivery of the child, the umbilical cord is sterilized with 5 per cent solution of iodine and cut. The end of the cord, which is still attached to the placenta, is placed in a sterile flask and the blood from the placenta is collected in this flask which contains a preservative solution. It is possible to collect between 100 c.c. and 150 c.c. of blood in the average case. Specimens of the placental blood are taken separately for blood grouping and serologic determination. When these data are available, the blood can be pooled in larger flasks for use when indicated. It has been shown that placental blood contains about 50 per cent more cellular elements and has 20 to 30 per cent greater coagulating power than has systemic blood of adult human beings. This method of transfusion is obviously important to certain obstetric and pediatric clinics and hospital services.

SUMMARY

Professional or nonprofessional donors can be used for blood transfusion. The blood may be given directly or indirectly and, if the latter method is employed, the blood may be stored and used as needed. The technique of indirect transfusion is not difficult if a simplified apparatus is used.

The most common signs and symptoms of reaction to transfusion are: rise in temperature, chill, and urticaria. Reactions such as dyspnea and cyanosis are less common. It has been erroneously assumed that a reaction to a transfusion cannot occur if a patient is anesthetized; I wish to emphasize that reaction may occur even if a patient is under anesthesia. The reactions may not be so obvious as when the patient is not anesthetized, but the symptoms can be detected if the observer is vigilant. It is also a false impression that tetanus antitoxin can be given with impunity when a patient is anesthetized. Reactions may occur also in these instances.

Many agents have been recommended as anticoagulants; such are sodium citrate, sodium oxalate, saline solution, peptone, and heparin. Many other agents have been tried, but sodium citrate is still the anticoagulant most commonly used in the indirect method of transfusion. Considerable interesting work is being done now on the use of heparin as an anticoagulant. Recently it has been found possible to obtain larger quantities of heparin from lungs of beef than from hepatic tissue and this discovery has been a great impetus to further research with this substance.

In certain localities donors have been heparinized a day or so prior to the time when their blood was to be used for transfusion. This procedure entails injecting solution of heparin into the donor's vein for a certain period and subsequently withdrawing his blood before the heparin has lost its power as an anticoagulant or has become inactivated. It is felt that heparin, the action of which is supposedly more in consonance with physiologic processes than most other anticoagulants, will cause fewer reactions. The action of heparin when injected intravenously is to render the blood incoagulable by preventing the conversion of prothrombin into thrombin. Heparin also may be added to blood, in the same manner as is sodium citrate, but the duration of its anticoagulant action is usually limited to twenty-four hours. As yet there are not sufficient data concerning the incidence of reaction to justify a declaration whether or not heparin will be more satisfactory than other anticoagulants.

It is important, however, that the incidence of reactions from transfusion be minimized, because Sibley¹³ and Lundy have demonstrated that, on the tenth day after transfusion, the increase in total hemoglobin of a group of patients who had no reactions was 50 per cent more than the increase attained by patients who had reactions.

COMMENT

When small children are to be given transfusions of blood, the use of pentobarbital sodium^{12, 14} (nembutal) in doses sufficient to keep the patient quiet will make the procedure easier. Apprehensive adults also

may be given pentobarbital sodium prior to transfusion with definite advantages. Further suggestions to facilitate venipuncture have been published elsewhere.¹⁰

The indications for blood transfusion are many, but some of the most common indications are the presence of one or more of the following: (1) shock owing to loss of circulating blood, (2) hemorrhagic diseases and blood dyscrasias, (3) debility with or without secondary anemia. Transfusions of from 1,000 c.c. to 5,000 c.c. of blood are not uncommon and are particularly indicated in shock owing to loss of blood and tissue fluid. When such large amounts of blood are administered, it is best to insert into the vein a needle which has a stylet. Then the slow drip of blood can be stopped for periods of one-half hour and the stylet can be inserted and left in place until it is desired to resume the transfusion. By this method the same needle and vein can be used for two or three days. Sometimes gold-plated needles are used for such prolonged transfusions because there is less tissue reaction at the site of venipuncture. Immunotransfusions are being used more extensively than before in cases of anterior poliomyelitis, measles, scarlet fever, and various forms of septicemia, but, as yet, there is no volume of evidence to make the procedure standardized. In certain cases, however, immunotransfusions have been remarkably helpful.

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SUMMARY

Professional or nonprofessional donors can be used for blood transfusion. The blood may be given directly or indirectly and, if the latter method is employed, the blood may be stored and used as needed. The technique of indirect transfusion is not difficult if a simplified apparatus is used.

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Editorials

Pathologic Physiology and Diagnosis of Jaundice

IN THE study of jaundice there has often been confusion of two topics which are clearly distinct; i.e., (1) the site of formation of bilirubin and (2) the mode of development of jaundice.¹ In other words, simple overproduction of bilirubin, whether it occurs in the Kupffer cells of the liver or in other reticuloendothelial or mesenchymal cells, is not synonymous with jaundice.

Rich² classified the various forms of jaundice in two groups, depending upon which of two fundamental abnormalities was present. In "retention" jaundice bilirubin is supplied to the circulating blood more rapidly than the liver cells are able to remove it; other bile constituents, however, are not accumulated, and probably as a result (although exact information is still needed on this point) the van den Bergh reaction is delayed or indirect in type, and bilirubin is not found in the urine regardless of the degree of hyperbilirubinemia. In "regurgitation" jaundice it is probable that whole bile is returned to the blood stream; in consequence the van den Bergh reaction is direct in type, and bilirubinuria is observed at relatively low levels of hyperbilirubinemia (usually at concentrations above 2 mg. per cent).

The clinical applicability of Rich's classification is made somewhat difficult by the frequency with which "retention" and "regurgitation" factors are present in the same individual. Hepatocellular injury is obvious in cases of jaundice due to diffuse parenchymal liver damage, such as that occurring in acute or subacute atrophy, cirrhosis, chronic passive congestion, neoarsphenamine jaundice, and with various severe infections. It might be supposed that the jaundice in these cases was solely "retentive," and in the early stages or milder degrees it appears that this is often true. Thus in cardiac jaundice, likewise in that due to arsphenamine, the van den Bergh reaction is often for a time delayed or indirect, and bilirubin is not demonstrable in the urine, but as the severity of the condition increases the van den Bergh reaction becomes direct and bilirubinuria appears. The experimental studies of Hiyeda³ and Itoh⁴ have shown that the "regurgitation" of bile in instances of diffuse liver damage, such as that due to toluylendiamine poisoning in dogs, is due to injury of the terminal portions of the bile capillaries with resultant increase in permeability. The ensuing jaundice was shown to be due to "diapedesis" of bile into the surrounding lymphatic

spaces. This type was contrasted with the jaundice due to obstruction of the larger bile ducts, and again it was found that the leakage of bile occurred from the terminal or ampullary portion of the bile capillaries; in this type, however, regurgitation of bile was due to actual "rhexis" of the bile capillary wall as a result of the gradually increasing intrabiliary pressure. It is of significance that the end-result in both types is much the same; i.e., escape of bile into the lymphatic spaces, thence to the thoracic duct and finally the circulating blood. Thus, while there are probably two modes of regurgitation of bile, the end-result is the same so far as concerns the appearance of a direct van den Bergh reaction and of bilirubin in the urine. From the clinical viewpoint, especially the question of prognosis and the desirability of surgery, it is clearly not enough to determine simply that the patient has "regurgitation" jaundice. In other words, the qualitative van den Bergh reaction has not proved of value in the clinical distinction of jaundice due to diffuse parenchymal liver damage from that due to obstruction of the larger bile ducts. The qualitative van den Bergh test has proved of chief value in the distinction of "hemolytic" jaundice, which represents the most often encountered member of the "retentive" type. It should be emphasized that the indirect or purely delayed van den Bergh reaction, although a regular finding in hemolytic jaundice, is not to be regarded as pathognomonic of this disease. As noted above, this type of reaction may be observed in various forms of liver dysfunction of mild degree. One condition most readily confused with hemolytic jaundice, if the van den Bergh reaction alone is the diagnostic criterion, is the relatively rare "constitutional hepatic dysfunction,"²⁵ or simple cholemia of Gilbert. This affection simulates familial hemolytic jaundice in the mild degree and long duration of the icterus, in being "acholuric," and in exhibiting an indirect or purely delayed direct van den Bergh reaction. In other respects the conditions are quite dissimilar; splenomegaly, increased reticulocyte percentage, fragile microcytes, and increased excretion of urobilinogen in the feces are all lacking in constitutional hepatic dysfunction. It is well to point out that urobilinogen may or may not be present in excess in the urine in either condition. Increases are by no means always encountered in hemolytic jaundice, as has often been believed. Cases of hemolytic jaundice with little or no increase of urobilinogen in the urine also have less retention of bilirubin in the plasma. At times there may even be a total absence of jaundice in spite of a marked increase in the rate of hemoglobin wastage. In one case studied by the writer there had never been jaundice and the outstanding symptoms were splenomegaly and profound anemia. Examination of the feces revealed an increase in urobilinogen of about five times normal. The urine in this case did not contain any excess of urobilinogen. The blood exhibited fragile microcytes and an increased percentage of reticulocytes. Splenectomy was curative. It was clear

that liver function in this patient was entirely capable of keeping up with the increased pigment metabolism. The findings bear out the statement made at the beginning of this discussion; i.e., that increased bilirubin formation and the appearance of jaundice are not synonymous.

Of chief clinical importance is the differential diagnosis of the various forms of regurgitation jaundice, those which are characterized by bilirubinuria and direct van den Bergh reaction. From the standpoint of prognosis and management these may be classified in three groups: (1) calculous jaundice, (2) cancerous jaundice, and (3) parenchymal jaundice.

In the distinction of the three groups mentioned, the physical examination should be especially careful with relation to the gall bladder, which, if distended and palpable, points most strongly toward cancerous biliary obstruction; and to the spleen, which, if appreciably enlarged, is very suggestive of parenchymal jaundice. The size and character of the liver is important, large livers having little differential significance except if they contain distinct nodular metastases; small livers, however, being much more indicative of cirrhosis or atrophy, that is to say, of parenchymal jaundice. Ascites is often difficult of interpretation; if fluid obtained at the first paracentesis has the characteristics of an exudate, and particularly if it contains mucin by the acetic acid test,⁶ the jaundice is much more likely to be cancerous. "Foetor hepaticus," the hepatic or amine odor,^{6, 7} a peculiar somewhat musty and sweetish odor which may even pervade the entire room in which the patient lies, is almost pathognomonic of liver atrophy. In the writer's experience this odor has been encountered in but five of a series of about 200 cases of jaundice; acute or subacute atrophy of the liver was present in each of the five.

The depth of jaundice is by no means solely dependent upon the degree of biliary obstruction or the disturbance in bilirubin excretory function of the liver. In the presence of complete biliary obstruction the depth of jaundice is directly proportional to the rate of wastage of hemoglobin.⁸ Associated blood loss results in compensatory slowing of this rate with consequent rednetion of jaundice, since the supply of bilirubin is diminished and there is constant loss in the urine. A marked decrease in jaundice is often wrongly ascribed to a release of the complete biliary obstruction, when in reality it is due to decreased bilirubin formation as a sequel to gastrointestinal bleeding. If the urobilinogen excretion in the feces is determined in such instances, it will be found not to have increased.¹⁰

When the rate of blood destruction is actually increased and at the same time the bilirubin excretory function of the liver is seriously impaired, the accumulation of bilirubin in the plasma will obviously proceed more rapidly and the depth of jaundice will be correspondingly great. This is not infrequently the case in severe parenchymal jaundice,

such as acute or subacute atrophy, the more severe and prolonged cases of acute catarrhal jaundice, and in some instances of cirrhosis. When the depth of jaundice is marked because of an increased rate of blood destruction, the reticulocyte percentage will often be found elevated.

The degree of biliary obstruction or of diminution of bile flow is a matter of distinct importance in the differential diagnosis of the three groups of jaundice mentioned above. Information on this point can be obtained best by determination of the amounts of urobilinogen excreted in the feces.^{9, 10} Because of the inconstancy of bowel movements and the varying dilution of the feces, it is necessary to determine the per diem excretion for a given period of time. In the writer's studies^{9, 10} comparisons were based on the average output over a four-day period. It was found that cancerous jaundice was characterized by complete biliary obstruction, not more than 5 mg. of urobilinogen per day appearing in the feces and not more than traces in the twenty-four-hour urine. The term "cancerous jaundice" did not include cases of primary or metastatic carcinoma of the liver, in which jaundice of appreciable degree but rarely occurs. Up to the present time, 56 cases of cancerous jaundice have been investigated with respect to per diem urobilinogen excretion. In 53 of this group the per diem amount of urobilinogen was less than 5 mg., although in 1 of these cases the amount later increased to over 70 mg., an increase which was associated with local signs suggesting that an internal biliary fistula had become established. In 3 cases the amount was more than 5 mg. per day. One of these, with a carcinoma of the gall bladder involving the common duct, excreted 7.5 mg. and 7.2 mg. daily during the two four-day periods of study. In the other 2 cases there were polypoid tumors in the common duct which were responsible for incomplete obstruction; 1 of these followed over a considerable period of time, exhibited intermittent complete obstruction, and at operation it was clear that the polypoid tumor just above the ampulla of Vater had acted as a ball valve. In contrast with the cancerous group are the results in 49 cases of calculous jaundice and 62 cases of parenchymal jaundice, the latter series including acute catarrhal jaundice, acute atrophy, and cirrhosis. On the total of 111 cases of both groups, only 5 excreted less than 5 mg. of urobilinogen per day in the feces. In 3 of this number biliary obstruction was due to a common duct stone, while in 2 there was complete cessation of bile flow associated with liver disease. One of the latter had neoplasmin jaundice; the other had acute yellow atrophy of undetermined etiology. In this connection it may be noted that 5 cases of acute or subacute atrophy of the liver were included in the parenchymal group; in 4 of these the per diem urobilinogen was more than 5 mg. per day, in other words more than what may be spoken of as the "cancerous" range. Several cases of cirrhosis were encountered in which, despite an obvious

element of regurgitation jaundice, the amounts of urobilinogen in the feces were considerably greater than normal, a finding indicative of an increased rate of blood destruction.

The characteristic complete obstruction in "cancerous" jaundice is without doubt related to the infiltrating and stenosing effect of the neoplasm. On the other hand, it is believed that complete obstruction in calculous jaundice is but rarely encountered because of the constantly dilating effect of a common duct stone. Even when stones are impacted in the ampulla, the egress of small amounts of bile is usually permitted, and over a four-day period this is reflected in an increase of the per diem urobilinogen above the "cancerous" range.

Hemolytic jaundice is readily distinguished from each of the three above groups, by virtue of indirect or delayed van den Bergh reaction, absence of bilirubin in the urine, increased excretion of urobilinogen in the feces, and elevated reticulocyte count.

It is believed that an increase of urobilinogen in the urine, over the normal limit of 3.4 mg. in twenty-four hours, is evidence at least of temporary liver dysfunction. The increase is most marked and constant in instances of parenchymal jaundice, particularly those in which there is an associated elevation of the rate of blood destruction, such as in the cases of hepatic cirrhosis, or prolonged and severe catarrhal jaundice exhibiting macrocytic hemolytic anemia.¹⁰ Considerable increases are not uncommonly observed in familial hemolytic jaundice; on the other hand, there is often no increase whatever even though a severe hemolytic process is present. There is much reason to believe that the increases which are seen in hemolytic jaundice are due to actual liver dysfunction, not to simple overflow because of the excessive formation of urobilinogen.¹¹ It should not be assumed that the urine urobilinogen is regularly increased in the parenchymal jaundice group. In occasional cases the reduction in bile flow may be so marked that the amount of urobilinogen returning to the liver becomes relatively insignificant. In these cases even ordinarily normal amounts must be evaluated; for instance, if the per diem output in the feces is but 10 mg., that in the urine 2 mg., the latter value would strongly suggest liver damage when the stool-urine ratio is taken into account. In some cases of parenchymal jaundice, particularly cirrhosis, the increase of urobilinogen in the urine is intermittent and may not be observed unless several twenty-four-hour determinations are made.

Prognosis and management of the jaundiced patient depends upon distinction of calculous, cancerous, parenchymal, and hemolytic forms. In calculous jaundice, operation should be deferred in the hope that the jaundice will recede, as it most often does. Operation can be carried out with considerably less risk after the jaundice has disappeared or greatly diminished. If the jaundice does not recede within two weeks (no increase in the feces urobilinogen and no decline of serum bilirubin),

then the common duct should be explored. Operation, if advisable at all, should be carried out earlier in cancerous jaundice since here the chances of release are almost nil. In parenchymal jaundice medical management alone is to be considered, with the exception of certain cases of hepatic cirrhosis associated with splenomegaly and macrocytic hemolytic anemia, in which splenectomy may be of value.⁷ Splenectomy is usually desirable in cases of familial hemolytic jaundice.

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Regarding Practices Frequently Used for Prevention and Treatment of Postoperative Distention

COMMENT was made in a recent editorial upon the extent to which the profession retains empiric practices, frequently carrying useless or harmful therapeutic customs from decade to decade without proper scientific warrant. Particular reference was made to the unphysiologic practice of promiseously giving postoperative enemas: "A patient who has abdominal distention and complains of gas pains is frequently treated by the administration of enemas and flushes. It is irrational to assume that the gastro-intestinal tract which is functionally inactive and already unable to empty itself of its contained fluid and gas will function normally after further overloading it by the administration of additional fluid in the form of an enema. Everything else

being equal, the degree, the extent, and the duration of post-operative distention and gas pains are directly proportionate to the number and the size of the enemas and the flushes administered, and yet how many physicians will allow a patient to go 1, 2, or even 4 days without having a bowel evacuation because the necessity of daily evacuation has been empirically used.'³

It is my belief that not only is the enema frequently used to the disadvantage of the patient postoperatively but that the following commonly practiced procedures also frequently predispose to postoperative distention and discomfort; and that these measures should not be used promiscuously and without indications of more clear-cut character than those commonly accepted: (1) the preoperative enema; (2) preoperative catharsis (in general abandoned at present but still practiced to some degree and extent); (3) preoperative and promiscuous postoperative administration of so-called specific "gut toning" drugs; (4) insertion of rectal tubes of undue dimension for relief of "gas pains"; (5) unindicated bladder catheterization; and (6) routine proctoclysis.

The mechanisms which control gut tone, the exact distribution of sympathetic and parasympathetic endings in parts of the gut wall, the methods of reactions of the nerve endings and the musculature itself to different stimuli are in some respects controversial points with physiologists and neurologists. No definite evidence can be offered at present that predisposition to distention may *not* occur from improper use of the measures just cited; whereas, some logical experimental and clinical experiences indicate that these measures may predispose to distention.

What sound physiological evidence has ever been produced to show that harm will arise from a normal amount of fecal matter lying in its normal habitat during and for a short time after a routine operation? Is it not more physiologic to leave it so since it is normally present, since perhaps it might in itself by mechanical or chemical means assist in maintaining the normal gut tone? Hewlett, in speaking of lack of normal stimuli to the gut, says: "The transportation of material through the intestinal canal is governed chiefly by the action of the intestinal contents upon the local nervous mechanism and muscle fibers of the surrounding intestinal wall. The stimuli which exert this action may be of a chemical or mechanical nature. Among the chemical substances that normally influence the movements are certain products such as carbon dioxide, marsh gas, skatol, etc."² Attempts to remove fecal matter in the colon preoperatively may result not only in a mildly irritating solution but also in variable amounts of air being frequently introduced as well. And undoubtedly both parts of the enema solution and introduced air are frequently retained to be absorbed or possibly to produce reflex disturbances in the entire intestinal tract.

Alvarez showed that pieces of muscle excised from the gut wall of a purged rabbit were more irritable than normal in some instances and

that in others the segments would hardly respond to stimulation at all.¹ Though expulsion of the enema, we assume, is prompted chiefly by stretching the smooth muscle, it would seem that a soapsuds enema may be as irritating at times to the mucosa of the colon as a cathartic, thereby possibly setting up mucosal reflexes which, allied with muscle stretching, might create, after the enema, more initial spasticity followed by inactivity and diminished tone than is normally present.

For the past six years, we have avoided the promiscuous use of both the preoperative and postoperative enema, ordering it only in special instances where, for example, surgery upon the colon was anticipated or when especially indicated postoperatively. Since adopting this routine, it definitely seems that postoperative distention in our patients has been less frequent and severe.

Surely a consideration of the fundamental laws of intestinal physiology, some of which have been discussed above, together with an appreciation of the transient action of at least some stimulants commonly recommended for prophylaxis against postoperative distention, would indicate that the routine prophylactic administration of such drugs is fallacious therapy. It seems logical to assume that preoperative stimulation of a normally functioning gut in an attempt to increase its tone postoperatively is not only to stimulate needlessly the mechanisms concerned in maintaining the tone but thereby possibly to predispose to greater relaxation and later distention through this needless stimulation. Morphine as usually administered procures, if the work of Ochsner and the observations of certain physiologists are to be accepted, a mild and more desirable prophylactic segmental stimulation of the gut than is to be obtained with extracts of the pituitary gland.

Colon or rectal tubes of large size should not be inserted in the rectum to allow passage of gas through unduly spastic sphincters. An ordinary urinary catheter sufficiently new that the walls will not be collapsed by the sphincters certainly has a lumen amply large for passage of gas. Only those who have had large rectal tubes inserted and compared with ordinary No. 16 F catheters can appreciate the contrast in comfort between the two tubes. It often is not sufficiently appreciated how much tiresome discomfort a sensitive patient may obtain from the sphincters being dilated by a large colon or rectal tube which is allowed to remain within the rectum over varying periods of time. Unnecessary stretching of the sphincters through afferent impulses causes reflex stimulation of sympathetics, thereby possibly predisposing to inactivity and distention of the bowel.

Laws regarding the sensitivity of reflex action may be applied to unnecessary catheterization. Hewlett says, in speaking of intestinal tone: "Nervous reflexes may diminish the intestinal movements as has been shown by experiments on animals (compression of the testicles). . . ."²

Urinary catheterization is a painful procedure to some people. It is not proper here to enter in a discussion regarding when catheterization should and should not be done. An unduly distended bladder in post-operative patients is undesirable, but we do believe that catheterization is ordered routinely more frequently than it should be.

Regarding routine proctoclysis only a few words will be said. A proctoclysis is, in a sense, a retained enema. Through mechanisms discussed above, may it not frequently be a source of postoperative discomfort not only directly but secondarily by reflex disturbance of the intestinal tract, predisposing to stimulation of sympathetics and distention? It should not be used routinely; only on special indication.

All in all it would surely seem, on consideration of sound physiologic principles, that it is a common tendency to tamper entirely too much with the intestinal tract pre- and postoperatively; and our clinical experience would indicate that the incidence of postoperative distention may be decreased by a more general consideration of relevant physiologic laws.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

OBSTRUCTIVE JAUNDICE

A CRITICAL REVIEW

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ALTHOUGH jaundice is merely the clinical evidence of an underlying pathologic process and is not a pathologic entity in itself, its appearance is so significant and may be so serious that it has come to be regarded and discussed almost as if it were a disease. In spite of the very valuable contributions to the subject which each year brings forth, jaundice still presents many serious and unsolved problems. Within the last few years a few almost revolutionary facts have been revealed concerning so-called obstructive jaundice, the type with which this review is concerned, and there is a continued emphasis upon other and older facts and theories.

CLASSIFICATION

It is now generally accepted that jaundice will occur whenever there is a disturbance of balance between the amount of bilirubin delivered to the liver for excretion and the capacity of the liver to excrete the pigment delivered to it. At that point, however, agreement ends, and this is particularly true of the classification of jaundice, a consideration which is of basic importance in any discussion of the condition.

The classification proposed by McNee¹ in 1923 was a distinct advance over anything which had preceded it, and it is still in very general use because it is simple and convenient. It includes obstructive hepatic jaundice, which implies mechanical interference with the flow of bile through the extrahepatic channels; toxic or infectious jaundice, which implies a block in the hepatic filter, the result of toxic or infectious injury of the hepatic cells, and hemolytic jaundice, which implies an increased rate of destruction of the red blood cells and a resulting production of bilirubin beyond the excretory capacity of the liver to care for.

In 1933 McNee,² defending this classification before the Royal Society of Medicine, pointed out that it was almost universally misquoted be-

cause the word hepatic was almost universally dropped from the first two groupings, an omission, he went on to say, which carried with it a complete loss of emphasis upon the role of the liver in the production of jaundice. He declared further that his classification had helped to change Minkowski and Naunyn's original statement, "Ohne Leber, kein Ikterus" (without the liver, no jaundice), into Aschoff's later statement, "Ohne mangelhafte Ausscheidung des Gallenfarbstoffs durch die Leber, kein Ikterus" (without defective excretion of biliary pigment via the liver, no jaundice).

McNee's apologia is true as far as it goes, but it does not go far enough. It does not overcome the fundamental misconception of the classification, natural enough when it was advanced, which is the postulate that the bilirubin in the blood differs in different varieties of jaundice. That idea was completely overthrown a few years later by the work of Harrop and Barron,³ which is excellently summarized by Rich,⁴ about as follows:

Pure bilirubin at the pH of the blood gives the direct or immediate van den Bergh reaction, but in normal plasma it gives the indirect reaction, because of the absorption of the bilirubin by the plasma proteins; as a result, the pigment is prevented from reacting promptly with the reagent. When, however, substances such as bile salts and cholesterol, which are present in small quantities in whole bile and in increased quantities in the plasma in the various forms of jaundice, are added to the plasma before bilirubin is introduced, or are added at the same time as the bilirubin, the van den Bergh reaction remains direct, apparently because substances which lower surface tension seem to be adsorbed by the proteins more readily than bilirubin is adsorbed. When the protein molecules are covered with such substances, the pigment remains free.

In short, experimental and clinical studies have made it clear that, when the plasma bilirubin of a jaundiced subject is tested by the van den Bergh method, the direct reaction may be taken to indicate that whole bile, which contains bile acids and cholesterol as well as bilirubin, has been regurgitated into the blood stream. It may further be assumed that the underlying pathologic process is either an obstruction of the bile ducts or necrosis of the liver cells, for these are the two conditions which permit bile to escape from the canaliculi into the blood stream. On the other hand, the indirect van den Bergh reaction may be taken to indicate that the bilirubin in the plasma has not been regurgitated into the blood from the canaliculi but represents pigment which the liver has not been able to remove from the blood stream. Obviously, then, the underlying pathologic process is an overproduction of bilirubin or a depressed excretory function of the liver, or a combination of these two states. The biphasic van den Bergh reaction can occur as the result of a high degree of pigment retention, without regurgitation, or under certain

circumstances of biliary regurgitation caused by obstruction or by necrosis of the liver cells.

On the basis of this work, Rich proposed a new classification of jaundice into the retention and the regurgitant varieties. In the retention type the bilirubin circulating in the blood stream is only partially excreted by the liver. The remainder accumulates in the blood, where it is bound, probably to the plasma proteins, and therefore does not pass through the kidneys into the urine. This type of jaundice is associated with mild forms of liver injury, chiefly cloudy swelling and cell atrophy, and is a secondary complication of such diseases as hemolytic anemia, congestive heart failure, pneumonia, and other diseases which are characterized by anoxemia and fever. In such diseases the jaundice is due partly to an increased formation of bilirubin and partly to a depressed excretory function of the liver. The van den Bergh reaction is indirect.

In the regurgitant type of jaundice the bilirubin circulating in the blood stream is excreted by the liver cells and escapes into the tissue spaces and blood sinusoids of the liver because of the rupture of the bile canaliculi. The larger bile ducts are obstructed, or the liver cells are necrotic, or both conditions occur in combination, and, as a result, both bilirubin and whole bile escape into the blood stream. The bile pigment is not bound and therefore can be excreted by the kidneys into the urine. This type of jaundice is associated with the major hepatic disorders and with mechanical obstruction of the extrahepatic bile ducts. The van den Bergh reaction is direct.

Although the classification advanced by Rich undoubtedly rests upon a sounder basis than the earlier classification of McNee, it is rather generally ignored. Because it requires for its comprehension and employment a more exact knowledge of the fundamental pathology of jaundice, many writers state frankly that the average practitioner is better equipped to use the classification of McNee. Convenience and simplicity, however, do not compensate for unsound premises. Rich's classification has no therapeutic intent and should not be condemned on that basis, as it very often is. Furthermore, although obstructive jaundice, strictly speaking, includes both the intrahepatic and the extrahepatic varieties of obstruction, common usage has so long attached to the term the limited implication of mechanical extrahepatic occlusion that it will probably continue to be used in that sense without serious confusion. It is so used throughout this paper.

Elton⁵ advances a "working hypothesis" for the mechanism of jaundice, based on the premise that the forms of bilirubin differ qualitatively. By his theory, bilirubin, as it passes through the liver, is changed to a water-soluble, crystalloid bilirubinate, which gives a direct van den Bergh reaction, while the unaltered form gives an indirect reaction. It seems far more reasonable to accept the work of

Harrop and Barron and to explain the direct and indirect van den Bergh reaction by the presence or absence of bile salts in the blood. Elton's division of the liver into major functional zones, the acceptance zone and the excretion zone, and an intermediate conversion zone, seems unsupported by the evidence now available.

EXPERIMENTAL AND GENERAL

The comprehensive review of the experimental aspects of jaundice which was published by Mann and Bollman⁹ in 1935 still remains the most valuable single contribution to this phase of the subject. Regardless of how obstructive jaundice is produced, they point out, its results are due to three factors; namely, the effect on the body cells of the retention of bile in the blood and in the tissue fluids, the effect of the absence of bile or the alteration of bile in the gastrointestinal tract, and the effect of the hepatic injury which accompanies jaundice. Complete loss of bile is compatible with life for an indefinite period of time if adequate care and a suitable diet are maintained. Nutritional disturbances are due to loss of normal bile from the gastrointestinal tract, plus the effect of retention of bile. The anemia and the diminution of plasma proteins are due partly to dietary and absorptive factors and partly to associated hepatic injury. An important clinical consideration is pointed out in this connection: These findings suggest the addition of large amounts of meat to the diet, but actually the jaundiced animal does not tolerate such a regimen over any period of time. Life can be prolonged indefinitely, however, on a diet which includes milk and syrup. Ascites may occur under conditions in which it does not usually occur in the nonjaundiced animal. Finally, bile salts continue to be formed, though in somewhat reduced amounts, until increasing hepatic damage entirely prevents their formation.

Walters and his associates^{7, 8} have contributed valuable discussions on the pathologic physiology of stone in the common duct, and Snell¹⁰ has studied the same condition in relation to the structure and functions of the liver. After classifying into four groups the sixty-three cases which form the basis of his study, he concludes that in two-thirds of such patients the hepatic lesions are transient and relatively minor, and offer no great obstacle to recovery. The remaining third includes the cases which are more serious and which exhibit various degrees of degenerative or destructive lesions of the parenchyma, proliferation of connective tissue and cirrhosis, and cholangiectasis and cholangitis, all associated with disturbances of hepatic function.

Rozendaal, Comfort, and Snell,¹¹ in a study of 138 individuals without hemolytic disease, found increased concentrations of bilirubin which they took to indicate hepatic dysfunction, either constitutional or secondary to hepatic injury. Such patients are prone to "bilious attacks" and exhibit intermittently or even constantly a mild degree of

jaundice which may later terminate in definite choleeystic disease, as happened in 29 per cent of the cases in this series. The authors note pessimistically that many of the other patients in the group are young and may later fall victims to such disease. They recommend a wider use of the bilirubin test both to demonstrate individuals likely to develop choleeystic disease and to reveal unsuspected cases of mild functional and organic disturbances of the liver.

This conception is of special interest to those who believe, as we do,^{11, 12} in Henschen's^{13, 14} theory of "liver weaklings." Our own conception of the so-called liver death is that certain individuals whose hepatic function is adequate for the stress and strain of ordinary life cannot withstand the added strain of surgery and all that it implies, and lose their lives because no provision is made for their "weak spot." We^{15, 16} have been using the Quick^{17, 18} hippuric acid liver function test in the preoperative study of many types of surgical subjects, and have found a rather surprising number of individuals who reveal an entirely unsuspected hepatic dysfunction but who have responded well to preoperative preparation. Such preparation is omitted in the usual case because the necessity for it is not evident, and that omission, we believe, is responsible for the occasional tragedy that follows simple elective surgery in presumably safe surgical risks. This conception is in line with Graham's¹⁹ repeated warning that individuals with damaged livers are questionable subjects for any sort of surgery.

It should also be remembered that, as Rozendaal's study shows, the existence of jaundice is apparently not incompatible with reasonably good health or even with perfect health.

ETIOLOGIC FACTORS

There is little new in the literature dealing with the etiologic factors of jaundice, although many reports testify to the unwisdom of fixed theories concerning their frequency. Thus, Heyd²⁰ lists in the order of frequency gallstones and infection of the extrahepatic bile ducts, catarrhal jaundice, hepatic degeneration, cancer of the liver, cirrhosis of the liver, cancer of the bile ducts or gall bladder, cancer of the pancreas, and metastatic carcinoma. Eusterman,²¹ on the other hand, lists gallstones, cancer of the pancreas, stricture of the extrahepatic bile ducts, congenital and acquired hemolytic jaundice, intrahepatic jaundice, primary neoplasms of the extrahepatic bile ducts, cancer of the gall bladder, acute and chronic pancreatitis, noncalculous cholecystitis, and a miscellaneous group, including general carcinomatosis, metastatic carcinoma, cholangitis, and primary carcinoma of the liver and duodenum. The general experience is that gallstones are the most frequent cause of obstructive jaundice, as in both these studies, but that carcinoma of the pancreas is a far more frequent cause than carcinoma of the liver, the bile ducts, or the gall bladder. Walton²² notes that his

personal incidence of carcinoma of the gall bladder (31 cases), as opposed to his personal incidence of carcinoma of the bile ducts (33 cases), is contrary to the usual figures, which show the latter condition to be twice as infrequent as the former.

Elton²³ studied the frequency of jaundice in a representative hospital population by means of a two-month survey of all the patients admitted to St. Mary's Hospital in Detroit. The incidence was 1 in every 8 patients, but in one-third of the cases the icterus was simply associated with interstitial blood extravasations following accidental or surgical trauma. A rather surprising range of conditions was revealed in the remainder of the cases. The study involved the use in all cases of the icteric index, the van den Bergh reaction, and the quantitative serum bilirubin test, and the author points out that failure to use the three tests in combination often will give rise to confusing and misleading conclusions, as will failure to use the proper standard (0.25 mg. per 100 c.c. of blood) for the serum bilirubin test.

There is an increasing emphasis upon noncalculous lesions of the ducts as a cause of obstructive jaundice. Ellsworth Eliot's²⁴ study of biliary strictures is perhaps the most complete available, but excellent reviews have also been contributed by Walters²⁵ and by Lahey.²⁶ Ladd²⁷ collected, from the records of the Boston Children's Hospital, 45 cases of congenital obstruction of the bile ducts, which he classified into seven distinct groups, and Donovan²⁸ collected 18 cases from the Babies' Hospital and St. Luke's Hospital in New York. Ladd considers that 37 per cent of his cases presented a possibility of cure, and his ultimate results suggest that choledochoduodenostomy is preferable to cholecystoduodenostomy. Donovan's outlook is more pessimistic, though, like Ladd, he emphasizes the importance of exploration in even the most hopeless-seeming cases. He points out also that the findings at operation may be incorrect, for two of his patients, in whom obliteration of the ducts was thought to be complete, were alive and well two and one-half and three years respectively after operation.

Diffuse contracture of the extrahepatic ducts, according to Ransom and Malcolm,²⁹ is hopeless if all the ducts are involved, though hepaticoduodenostomy may be useful if the hepatic duct is not occluded, and cholecystenterostomy is justified if the gall bladder contains bile. Patterson³⁰ describes a case of jaundice due to obstruction of the common duct by an aberrant vessel, and another case, which Graham³¹ is not inclined to accept, due to adhesions. Nicholson³² reports a case of jaundice associated with diverticulum of the duodenum and analyzes the 14 cases reported in the literature. Cystic dilatation of the common duct as a possible cause of jaundice is mentioned by Walton, who has personally seen 2 cases, and by Taylor,³³ who collected 4 cases, 2 of which were observed personally, over a ten-year period at the University Hospital in London. Pavel³⁴ describes functional obstructive jaundice due to

reflex spasm at the common duct sphincter. Medical treatment by the Einhorn tube is sometimes successful, but more often surgery must be resorted to, and the deviation of the bile must be carried out over a long period of time. His statement that surgery is without danger (from hepatitis) in long-standing jaundice indicates a casual point of view not likely to find general acceptance.

Potter³⁵ collected from the literature and from his personal records 432 cases of biliary tract disease in young subjects (under 15 years of age), in 209 of which jaundice was also present. Since youth is generally regarded as a point against the diagnosis of obstructive jaundice, these figures should be borne in mind. Penberthy and Benson³⁶ have called attention to the same possibility.

DIAGNOSIS

Eusterman's study of 533 cases of jaundice verified by operation or autopsy remains the best single study of the diagnostic errors which are possible in this condition. There will be general agreement with Ottenberg and Colp's³⁷ conclusion, based on a careful analysis of 84 cases, that no single sign, symptom, or test can be relied upon for diagnosis, just as all experience bears out Lord Moynihan's statement, now many years old, that no man living is infallible in the diagnosis of obstructive jaundice.

Eusterman lists as possible sources of error: the absence of any trustworthy specific test to differentiate the varieties of jaundice, especially when obstructive jaundice is painless or incomplete; the simultaneous occurrence of several lesions in the biliary tract of the same subject; the existence of pathologic conditions with which it is unusual to associate jaundice; and the existence of conditions difficult to recognize clinically which may produce mechanical jaundice. Ottenberg and Colp list as points of diagnostic value: pain, chills, a history of previous similar attacks, a history of the ingestion of toxic substances, the presence of a palpable spleen or of local rigidity, the occurrence of fever at the onset, and a group of laboratory tests upon which we shall comment later.

Ottenberg and Colp also warn against reliance on the presence or absence of pain to differentiate obstructive from nonobstructive jaundice, or to differentiate benign from malignant conditions. Rives, Romano, and Sandifer³⁸ make the same point in their analysis of 96 cases of carcinoma of the pancreas, in 48 of which pain was associated with the jaundice. Rhodes and Greenblatt³⁹ have called attention to this source of error in their study of 24 cases of carcinoma of the gallbladder, and we have noted it in our own study⁴⁰ of 25 cases of the same condition and in another study⁴¹ of 26 cases of carcinoma of the liver, in a small group of which pain and jaundice were associated. It must not be forgotten, too, as many writers point out, that gallstones may be present

along with a malignant process and may confuse the picture by the interjection of a type of colicky pain not supposedly associated with malignancy.

LABORATORY STUDIES

Martin's⁴² point is well taken that the biochemical study of jaundice has become almost too unwieldy to be useful and that abstinence from unnecessary tests is a desideratum in patients who are frequently so ill that they greatly appreciate being left undisturbed. One cannot, however, practice that precept too literally, for laboratory studies, and especially serial laboratory studies, often furnish information which is essential and which cannot be dispensed with.

Laboratory tests in jaundice fall into two groups, those which are employed to demonstrate the jaundice or to differentiate the varieties, and those which are designed to study the associated liver damage. In the former group the value of the icteric index, the serum bilirubin test, and the van den Bergh test is so generally accepted that no comment upon them is necessary. Certain of the newer and less generally employed tests should be mentioned briefly.

Opinion differs as to the value of the galactose tolerance test. Snell and Magath,⁴³ in an excellent review of such tests, state that it furnishes helpful but not altogether reliable information as to the possible hepatogenous or obstructive character of the jaundice, and Ottenberg's⁴⁴ opinion is much the same. White⁴⁵ considers that a positive test (showing 6 to 7 gm.) is practically conclusive evidence of liver degeneration, which is not, however, excluded by a negative result. Schiff and Senior⁴⁶ believe it to be very valuable in differential diagnosis. In a study of 100 cases of jaundice they found the test negative in all 20 cases of obstructive jaundice, but positive in 49 of 50 cases of catarrhal jaundice and in 14 of 15 cases of toxic hepatitis.

Ottenberg advocates the serial use of the test for cholesterol and cholesterol esters. The work of Epstein and Greenspan⁴⁷ has shown that in biliary obstruction there is associated with the increase in the total blood cholesterol a parallel though somewhat less marked increase in the percentage of cholesterol esters. Ottenberg, who advocates the serial use of the test, points out that the tendency in all forms of hepatic degeneration is for the proportion of esters to fall, sometimes to within the lowest range at which accurate determination is possible by present methods; whereas, in obstructive jaundice the fall does not occur until the terminal stages, when extensive hepatic degeneration has occurred. In the early stages of obstruction an increase in the values is not unlikely.

The reliability of the serum phosphate test seems debatable. Cantarow and Nelson⁴⁸ found such a wide overlapping of values in a study of 31 patients with obstructive jaundice and 22 patients with nonobstructive jaundice that they consider the test worthless for differential diagnosis.

In the same issue of the same journal Flood, Gutman, and Gutman⁴⁹ report that the test is useful in ruling out obstructive jaundice, an opinion which is shared by Rothman and his associates.⁵⁰

Ottenberg advocates the use of the Lichtman⁵¹ test for tyrosine in the urine. Tyrosinase is a vegetable enzyme, derived most conveniently from potatoes, and capable of specifically oxidizing tyrosine to produce a dark brown pigment, melanin, which lends itself readily to colorimetric estimation. A positive test is of diagnostic value; a negative test means little. Small amounts of tyrosine in the urine of jaundiced patients suggest subacute degeneration of the liver, or malignancy, while large amounts point to acute liver anolysis. Mild degrees of tyrosinuria may occur in catarrhal jaundice. The value of the test from the standpoint of differential diagnosis is not yet established.

Jacobi^{52, 53} has suggested that the glucose tolerance test be used to differentiate obstructive from nonobstructive jaundice and benign from malignant disease. In the obstructive variety of jaundice, he points out, the curve is still elevated at the end of a two-hour period; whereas, in the nonobstructive variety it falls promptly after the initial rise. When the test is repeated after the patient has been treated for two or three weeks with liver extract, a high carbohydrate diet, and large quantities of glucose, the curve is still elevated in malignant disease, but in benign states it assumes the character of the nonobstructive curve and falls sharply. The test is not yet in general use.

Foote and Carr⁵⁴ advocate the differential diagnosis of jaundice by fractional cholecystography. The dye is given intravenously, in divided doses, in combination with glucose, and radiography is repeated at intervals. Their latest report⁵⁵ covers 5 experimental and 15 clinical cases. By this method they believe they can say with assurance that, when the normal gall-bladder shadow is present at twenty hours but absent at forty-eight hours, intrahepatic disease is the cause of the jaundice; when the gall bladder or common duct is visualized at twenty hours and has not emptied at forty-eight hours, there is obstruction at or near the ampulla of Vater. They are unwilling to speak positively of the cases which show no shadow at twenty or forty-eight hours. Hunt, discussing the report, made the point that the method seems more exact in the experimental animal than as a clinical test, and questioned the wisdom of determining a therapeutic course on such tenuous evidence. It should be noted also that many experienced surgeons believe that the intravenous use of a dye, even when bolstered with glucose, is an unwise procedure in jaundice.

Sjostrom⁵⁶ has devised a test for the citric acid content of the blood serum, which, as Graham comments, eliminates the difficulty just mentioned. It is based on the premise that the liver cells contain an enzyme especially directed toward the citric acid metabolism, which

is damaged in hepatitis and also, though to a less marked degree, in jaundice due to stasis. In a series of 162 cases of diseases of the liver and bile ducts there was a prompt increase in the citric acid content of the blood serum in hepatitis, catarrhal jaundice, and cirrhosis, although the values remained normal until late in the disease in cholecystitis, cholelithiasis, and common duct obstruction. High values in these latter conditions indicated severe liver damage and presaged a high mortality. Graham's opinion is that the test seems of value in the differential diagnosis of jaundice and is worthy of an extended trial.

Von Purjesz⁵⁷ has described a simple method of demonstrating bilirubin in the urine, based on the oxidation of bilirubin to biliverdin by the use of sulfosalicylic acid and hydrogen peroxide. If bilirubin is present, a green coloration appears within fifteen minutes, ranging from olive green for small amounts to grass green for large amounts. The author claims that the test is both sensitive and reliable, and its simplicity should commend it to practitioners who lack elaborate laboratory facilities.

Malamud⁵⁸ studied the elimination of water in jaundiced patients by Volhard's test for induced diuresis. When normal patients are given a fixed amount of tepid, slightly sweetened, lemon-flavored tea, the urine voided in four hours is equal to or slightly in excess of the quantity of fluid ingested. In 18 of 20 jaundiced patients whose renal function was normal by standard tests, the quantity of urine voided over the four-hour period was markedly or slightly less than the fluid ingested, the degree of retardation depending upon the intensity of the jaundice. Other than demonstrating the effect of jaundice on the renal function, the test seems to have no clinical or prognostic value.

Brodrick and Cullinan⁵⁹ have devised a histamine test to demonstrate latent jaundice which cannot be demonstrated by the usual clinical or laboratory methods. When a minute quantity of histamine is injected intradermally, a deeply yellow wheal is raised if jaundice is present. Doubtful tests are regarded as negative. The histamine test was positive in 44 of 48 cases of obstructive and hepatogenous jaundice and negative in 22 normal controls; but, in spite of its apparent consistency, its limitations are obvious. The authors attribute the phenomenon to an abnormal permeability of the capillaries for bile pigment which is produced by the histamine and which allows the pigment to escape and concentrate in the wheal.

Mora and Jirka⁶⁰ used the Aldrich intracutaneous salt solution test in patients with obstructive jaundice and noted a marked diminution in the normal absorption time, with a prompt return to normal in 14 of 15 cases as the jaundice decreased. The explanation of the test is not clear.

We¹⁵ have personally used the Quick^{17, 18} hippuric acid test of liver function in a large number of jaundiced patients, and have found that it confirms the general idea that liver damage may or may not be asso-

ciated with the obstructive variety. It is interesting and very significant to trace the improvement in liver function after proper preparation for operation, as well as to note the fall in function after anesthesia and operation and the improvement as convalescence proceeds. Quick considers the test helpful in differentiating between obstructive jaundice, in which the values are likely to be normal or high, and catarrhal jaundice, in which they are likely to be markedly reduced. We should be unwilling to determine either diagnosis or therapy on this basis because of the many other factors which may confuse the values. Snell and Plinkett⁶¹ share our views on this point, as well as our favorable opinion of the value of this test. They found a general agreement between the Quick test and the more expensive and elaborate serum bilirubin test. Kohlstaedt and Helmer⁶² consider the extraction method described by Quick more accurate than the precipitation method in jaundiced patients, but we have found the simpler precipitation method entirely satisfactory.

DeCourcy,^{63, 64} who studied the blood iodine in various types of biliary tract disease, found in 5 cases of common duct stone an increase from a normal of 3 to 6 μg to an average of 2,090 μg . Experimental studies substantiated his clinical findings. He considers operation reasonably safe when the blood iodine has fallen to 100 μg or less, and points out that this test is superior to the dye test of liver function because it does not require the introduction into the blood stream of a potentially harmful agent.

THE HEMORRHAGIC DIATHESIS

Walters'⁶⁵ experience is the experience of many surgeons, that 50 per cent of all deaths following surgery on jaundiced patients are due to hemorrhage. For some reason this is not the experience in the Charity Hospital of Louisiana at New Orleans. In a study of 100 deaths following biliary tract surgery we⁶⁶ personally found among 35 jaundiced patients only 4 deaths which could possibly be attributed to hemorrhage, and Rives, Romano, and Sandifer found only 4 such deaths in 72 cases of jaundice due to carcinoma of the pancreas. It is a curious and inexplicable coincidence that in two series of cases involving jaundice of totally different origins there should prevail a situation which is entirely contrary to general experience.

The defective clot theory to explain the hemorrhagic diathesis in jaundice is discussed by Ivy and his associates,⁶⁷ by Carr and Foote,⁶⁸ and by ourselves.⁶⁹ There no longer seems any doubt that the clotting mechanism in certain jaundiced patients differs from the normal mechanism, as can easily be demonstrated by simple observation. As we have pointed out, in patients with a hemorrhagic tendency the clot is large and bulky; it does not retract normally; it wets a large surface area of

filter paper when it is transferred to it; and it promptly falls to pieces when it is handled. The clot in a normal patient, or in a jaundiced patient without a bleeding tendency, is smaller, firmer, and definitely retractile, and it shows no tendency toward disintegration when it is handled. Observation of the clot is therefore a simple precaution which can be practiced by any surgeon in any case.

It is easy to explain the defective clot on the basis of Quick's^{70, 71} studies. Both clinical and experimental evidence supports his theory of prothrombin deficiency as the most important, if not the only, cause of defective coagulation of the blood. Since the conversion of prothrombin to thrombin is a mass reaction, then a diminution in prothrombin necessarily is followed by a diminution in the production of thrombin, which in turn is followed by a diminution in the conversion of fibrinogen to fibrin, the essential element in a firm clot. A prothrombin deficiency is the fundamental cause, but a deficiency in the conversion of fibrinogen to fibrin is the immediate explanation of the character of the clot in patients with a bleeding tendency. Neither the bleeding time nor the clotting time is necessarily altered for a considerable period of time, regardless of the inadequacy of the mass reaction, for the conversion of fibrinogen to fibrin still occurs; the process is merely decreased; it is not eliminated. Indeed, Quick has shown that a critical level is not reached until the prothrombin content of the blood has fallen to 15 or 20 per cent. Further support of the theory of prothrombin deficiency is furnished by the experimental studies of Hawkins and Brinkhous⁷² on bile fistulas.

Another practical consideration is the observation of Ivy and his associates that the tendency to hemorrhage is more likely to be evident twenty-four to forty-eight hours after operation than at operation, because during this period abnormally fragile clots are likely to be dislodged by postoperative vomiting, restlessness, and similar factors. We ourselves have pointed out that free oozing is more likely to occur at operation than hemorrhage, because the clot plugs the severed vessels, even though it does not plug them adequately. We also have emphasized a consideration which seems to be generally overlooked, the serious and treacherous character of capillary bleeding.

Snell⁷³ and Quick⁷¹ recently have published very valuable summaries of the present knowledge of the hemorrhagic diathesis in jaundice. Three factors are associated with it. The first is the prothrombin deficiency demonstrated by Quick and his associates. The second is the vitamin K (koagulation) deficiency demonstrated by Dam⁷⁴ and by Ahnquist and Stokstad⁷⁵ and later confirmed by Quick,⁷⁶ who showed that, by the use of Ahnquist's diet, which is complete except for an adequate amount of vitamin K, a prothrombin deficiency was observed in chicks as early as the fourth day. When the prothrombin level

dropped below 20 per cent, a definite hemorrhagic tendency was invariably observed, though it could be promptly overcome by the use of small amounts of alfalfa, which is particularly rich in vitamin K. The work of Hawkins and Brinkhous and of Heyman⁷⁷ has shown, in addition, that in the absence of bile salts vitamin K is ineffective; their presence is clearly required for the normal absorption of fats and sterols from the intestine. Quick has also called attention to this point.

Many observers, Quick and his associates among them, are inclined to postulate that the prothrombin deficiency in the blood of certain jaundiced patients is the result of liver damage, and it must be granted that a large body of evidence, particularly the experimental and clinical evidence adduced by Quick in his most recent publication, goes to support that theory. The experimental studies of Roderick⁷⁸ and of Smith, Warner, and Brinkhous⁷⁹ also are in line with this conception. Logical as the reasoning is, however, we are personally still inclined to question an absolute cause and effect relationship between liver damage and the hemorrhagic diathesis; our personal studies⁸⁰ with Quick's own test of liver function have revealed a fair number of cases in which the hemorrhagic diathesis was evident and the liver function normal or approximately normal, though we must grant that we have also seen a few cases in which the bleeding tendency and a markedly deficient liver function were associated.

The gravity of the problem of the bleeding tendency in jaundiced patients, Quick points out, lies in the fact that its occurrence cannot be predicted with any degree of certainty by any method at all. As Ivy and his co-workers have remarked, the only way to determine whether a patient has a bleeding tendency seems to be to wait and see whether he is going to bleed. Various tests to determine this tendency have been devised. Carr, Foote, and Naffziger^{81, 82} suggest the use of the Grote⁸² test for sulfur compounds, on the theory that the clot in subjects with a hemorrhagic tendency is influenced by the collection of intermediate products of protein metabolism, such as cysteine and related forms of mereaptan. They profess satisfaction with the method in an extensive experimental study and a smaller series of clinical tests. We have not found this test reliable, and Ravdin and Riegel⁸³ question the role of sulfur compounds in the hemorrhagic diathesis.

In a small series of cases (7) Lewisohn⁸⁴ used an index arrived at by dividing by antithrombin the product of prothrombin multiplied by fibrinogen,^{85*} any value below 0.7 indicating a tendency toward hemorrhage. In this series the test seemed accurate, but its requirements put it beyond the reach of the average practitioner.

Nygaard,⁸⁶ of the Mayo Clinic, studied the coagulation time of the plasma. In 238 normal subjects the mean was 190 seconds, against a

*Moss' study of fibrinogen is very valuable.

mean of 250 seconds in 90 jaundiced subjects. The plasma reading itself may be used, or an index arrived at by dividing the normal plasma coagulating time by the plasma coagulation time of the case in question; the normal index is 1. In the group Nygaard studied, the 6 patients who died of hemorrhage all had indices under 1.1. As we have previously commented, there seems no clear reason why an individual with an index actually higher than normal should exhibit a bleeding tendency, and the question may be properly raised as to whether the plasma clotting time parallels the coagulation time of the blood.

Ivy and his co-workers⁶⁷ have described a test for the hemorrhagic diathesis in which the factor of capillary retraction is eliminated and the burden of controlling hemorrhage is put squarely upon the factor of coagulation. The venous return in the upper extremity is cut off by the application of the cuff of a sphygmomanometer, with a pressure of 40 mm. of mercury, and a state is thus produced comparable to the clinical state produced by anesthesia, operative trauma, and shock, which in combination may result in capillary paresis and hemorrhage. In an extensive series of cases it was found that most jaundiced patients with a bleeding tendency showed a definitely prolonged venous pressure bleeding time, while most of those without such a tendency showed a venous pressure bleeding time within normal limits (four minutes).

This test has the virtue of simplicity and certainly should be used in all jaundiced patients in combination with other tests. It has, however, certain obvious defects. For one thing, the puncture is so minute that it is a question whether the equally minute clot is likely to be seriously affected by a limitation of the venous return. For another, the arbitrary upper limit (four minutes) for normal bleeding time permits the inclusion within it of patients with a bleeding tendency. We have also noted that the venous pressure bleeding time tends to remain low in younger persons and to become elevated with age. Finally, we⁸⁰ have sometimes found the Ivy test normal when our own serum volume test, to be described later, indicated a definite hemorrhagic tendency, which in one case, at least, was proved by actual bleeding. A recent report by Boys⁸⁷ corroborates our opinion of this test. In a study of 35 cases the 9 patients who bled showed an elevated Ivy bleeding time, but so also did 15 of the 26 patients who did not bleed. This seems a very high percentage of what might be called negative error.

The serum volume test for the hemorrhagic diathesis in jaundice which we⁶⁹ have described requires only a syringe and a graduated tube. An arbitrary amount of blood, preferably 3 c.c., is collected and allowed to stand at room temperature for four hours. The clot is then removed and studied and the serum volume read. The index is determined by dividing the serum volume by one-half the volume of blood withdrawn. The standard of normal is 1, and indices below this level are progressively

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disease the oxygen saturation of the blood is markedly decreased, but can be readily improved by transfusion.

McNealy and his associates⁹⁴ advise the use of viosterol to counteract the bleeding tendency in jaundice, on the basis of an observation made by the late R. H. Jaffe and later confirmed by Greaves and Schmidt, to the effect that a deficiency of bile in the gastrointestinal tract is associated with a defective or impaired absorption of fat soluble vitamins, especially vitamin D. In the cases they studied, the administration of viosterol in 30 drop doses t.i.d., together with the administration of bile salts if the stools were acholic, practically always reduced to normal an unduly prolonged Ivy bleeding time; failure in a few cases could be explained by far-advanced or fulminating hepatic insufficiency. Boys⁸⁷ had good results with this plan of therapy except in two patients with extensive carcinomatosis. He advances the suggestion that perhaps failure under it may indicate an apparently permanent fat-soluble vitamin deficiency due to a malignant process. Johnston⁹⁵ in a similar study found the Ivy bleeding time improved in 23 of 24 cases treated by this method, and unimproved in 11 of 13 control cases. In a discussion of this report Zinniger called attention to the practical consideration that the routine prophylactic use of viosterol could scarcely be considered in public institutions, since the cost was approximately five dollars per patient. Gray and Ivy,⁹⁶ who studied the role of serum calcium fractions in the improvement following this type of therapy, found no significant alterations.

The use of vitamin K in the preparation of jaundiced patients for operation is the logical outcome of the studies which have been briefly outlined in this section. This vitamin⁹⁷ is particularly abundant in hog liver oil, cabbage, spinach, tomatoes, and alfalfa, from which a powder can be prepared, but it is not present in cod liver oil, wheat germ oil, carotene, cevitamic acid, egg albumen, or ultraviolet irradiation. Butt, Snell, and Osterberg,⁹⁸ among others, report excellent results from a preparation of fish meal, as suggested by Almquist,⁷⁵ in daily doses of 200 mg., which is almost ten times the necessary calculated dose of 23 mg. Whole human bile or bile salts were also used as indicated, to assist in the absorption of vitamin K as well as of vitamins A and D. Their studies cover a series of 18 patients with complete biliary obstruction. In view of our own unwillingness to accept liver damage as the chief cause of the hemorrhagic tendency, it is interesting to note that one patient who had demonstrated such a tendency did not exhibit it after operation, for which she had been carefully prepared, though she did lose her life from liver insufficiency. Quick, on the other hand, reported in very considerable detail a case in which the prothrombin deficiency paralleled the hepatic dysfunction, as did the improvement in both regards.

indicative of hemorrhage. The test is repeated as is necessary to determine the safe time for operation.*

A routine blood count is necessary to demonstrate anemia, for which the proper correction must be made; when it is present, the serum volume will naturally be greater than one-half the blood volume and the results of the test will be misleading. Also, the blood must be transferred quickly from the syringe to the tube, for the clot is defective if there is undue delay in this maneuver, and an unnaturally small amount of serum is expressed.

PREOPERATIVE THERAPY

Glucose still remains the sheet anchor in the preparation of jaundiced patients for operation, and the work of Althausen⁸⁸ on the value of its oral administration is worth careful consideration. Calcium also should be used, as suggested experimentally by Wright⁸⁹ and by Lee and Vincent,⁹⁰ and as applied clinically by Walters.⁹¹ It has been clearly proved that no calcium deficiency exists in such cases, either actual or functional, but such therapy has undeniably good results, perhaps, as Ravdin's⁹² studies seem to indicate, because of its effect on the liver.

The beneficial effects of blood transfusion are also clearly proved. Quick⁷¹ has shown that the value of this therapy is due to a replacement of prothrombin, which is in line with Hawkins and Brinkhous'⁷² observations that there is a large excess of this element in normal blood. Quick has demonstrated a wide margin of safety in the prothrombin factor, which may fall as low as 20 per cent without immediate danger of hemorrhage. A prothrombin concentration below 15 per cent is exceedingly serious and should be immediately combated by transfusion and other measures. These facts, it seems to us, make it perfectly clear why in these patients the loss of even small amounts of blood at operation or shortly after operation may be lethal and makes clear also, as we have previously emphasized, that preoperative transfusion cannot be expected to take care of postoperative hemorrhage. Finally, these facts put on a scientific basis Walters'⁹¹ suggestion that a period of eight to ten hours after transfusion in some cases is the optimum and the only safe time for operation.

Hawkins'⁹² experimental studies and Judd's⁹³ clinical observations point to anoxemia as an important factor in the hemorrhage of jaundiced patients as well as in the improvement which follows transfusion. Hawkins demonstrated an improvement in the coagulation time after the administration of oxygen, and Judd noted that in patients with hepatic

*Since this paper was completed, a negro female, with suspected malignancy of the biliary tract, revealed an initial serum volume index of 0.18. She did not respond to preparation by vitamin K and bile salts, and transfusion raised the index only to 0.70, and that temporarily. At the end of a month, in desperation, she was operated upon, with a SVI of 0.55. Exploration and biopsy revealed inoperable carcinoma of the gall bladder. She oozed freely at operation and died from intraperitoneal hemorrhage on the seventh postoperative day.

biliary decompression, which, by regulation of the bile drainage, also protects the patient from the asthenia likely to follow prolonged loss of bile salts unless these are added to his diet or he is re-fed his own bile.

According to Whipple's¹¹² latest contribution, the radical operation for carcinoma of the ampullary region and head of the pancreas devised by himself, Mullins, and Parsons¹¹³ has resulted in the survival for various periods to date of 5 out of 10 patients on whom it was performed. The eleventh patient survived operation but died of cholangitis and multiple liver abscesses at the end of five months. This is an extraordinary number of survivals in a group of conditions hitherto regarded as almost uniformly fatal.

In an experimental study of the results of various methods of exclusion of pancreatic secretion from the intestinal tract, we¹¹⁴ demonstrated several facts. In the first place, the digestion of fat and protein remained approximately normal, even when unusually large amounts of these substances were included in the diet, though fatty changes invariably developed when partial or complete pancreatectomy was added to ligation and division of the pancreatic ducts. In the second place, such changes did not develop in these animals when lecithin was included in the diet, or when the ducts were merely divided and ligated and the pancreas was left in situ. These findings seem to corroborate the demonstration by Dragstedt and his co-workers^{115, 116} of a pancreatic hormone which is able to take over the function hitherto assigned exclusively to the external secretion of the pancreas. On the basis of our experimental observations, it may be said that in malignancy of the ampullary and perampullary regions radical surgery which does not involve excision of the pancreatic tissue may safely be done without reimplantation of the pancreatic ducts, but that lecithin, choline, pancreatic substance, or alcoholic extracts of the pancreas must be administered to forestall fatty changes in the liver when the operation includes excision of the head or of the head and body of the pancreas.

COMPLICATIONS

Hebert¹¹⁷ has continued the experimental work of Mann and Bollman⁸ on the tendency of the jaundiced animal to develop peptic ulcers, particularly on the duodenal side. His studies show that in these animals the gastric acidity following test meals and the duodenal alkalinity are not materially altered, but that both the acidity and the amount of gastric secretion in the fasting stomach are decreased. There is also a reduction in the buffering capacity of the duodenal contents, which is still further reduced when ulceration is present. These findings, of course, can be applied to the human being only with many reservations, for man can live only a limited time with complete biliary obstruction, and unrelieved jaundice is rarely present for a sufficiently long time to permit comparison with experimental animals.

McNealy⁹⁹ has published an excellent outline of the preparation of the jaundiced patient for operation, which is complete in all details except for the very recent suggestion of the use of vitamin K and bile salts.

SURGICAL THERAPY

It is generally agreed today that exploration of the bile ducts should be routine in all cases of obstructive jaundice unless there is most absolute evidence that they are patent. The experience of all observers, of whom Lahey¹⁰⁰ is typical, is to the effect that as the percentage of explorations increases so does the percentage of stones found. Furthermore, since overlooked stones are the most frequent cause of secondary surgery, there is a corresponding decrease in the percentage of such operations and an actual decrease in the final mortality.

Allen and Wallace,¹⁰¹ among others, advocate dilatation of the ampulla of Vater with the Bakēs dilators. Their results are apparently good, but the recent experimental studies of Zollinger, Brauch, and Bailey¹⁰² introduce grave doubts as to the safety of the method. Their work demonstrates that the immediate result of this maneuver is hemorrhage and inflammation and that the permanent dilatation of the ampulla is actually less, as the result of scarring, than when simple cholecystectomy is done. Their clinical studies with perfusion pressures also show that the pressure is greater when the papilla is extensively dilated than when it is not explored. The plan of immediate cholangiography, as advocated by Payne¹⁰³ and by Best and his associates,^{104, 105} seems equally effective and far less dangerous.

Beall¹⁰⁶ considers that prolonged drainage of the common duct is definitely harmful, and regrets the only two cases in which over a twenty-year period he has used the method. He notes that the single similar paper in that period, by Richter and Buchbinder, was warmly approved by Halsted. Walton²² advocates common duct drainage only when there is definite suppuration and regards routine dilatation of the ampulla of Vater as more effective. He considers the T-tube dangerous and never employs it. Against the authorities who use common duct drainage cautiously or not at all must be set such writers as Payne¹⁰⁷ and Carter,¹⁰⁸ who advocate prolonged drainage, sometimes for several months. They determine the necessary period by studies of the function of the liver, studies of the state of the duct, and studies of the function of the sphincter of Oddi. Carter also suggests the use of specific therapy, such as bacteriophage, for the treatment of subacute pancreatitis.

Several writers, Ravdin and Frazier,¹⁰⁹ Culligan,¹¹⁰ and Sharples,¹¹¹ have pointed out that fatal consequences may follow the strain suddenly placed upon a damaged liver by the sudden release of complete obstruction. Our own¹¹ experimental observations clearly establish this risk. Ravdin and Frazier have devised an ingenious apparatus for gradual

biliary decompression, which, by regulation of the bile drainage, also protects the patient from the asthenia likely to follow prolonged loss of bile salts unless these are added to his diet or he is re-fed his own bile.

According to Whipple's¹¹² latest contribution, the radical operation for carcinoma of the ampullary region and head of the pancreas devised by himself, Mullins, and Parsons¹¹³ has resulted in the survival for various periods to date of 5 out of 10 patients on whom it was performed. The eleventh patient survived operation but died of cholangitis and multiple liver abscesses at the end of five months. This is an extraordinary number of survivals in a group of conditions hitherto regarded as almost uniformly fatal.

In an experimental study of the results of various methods of exclusion of pancreatic secretion from the intestinal tract, we¹¹⁴ demonstrated several facts. In the first place, the digestion of fat and protein remained approximately normal, even when unusually large amounts of these substances were included in the diet, though fatty changes invariably developed when partial or complete pancreatectomy was added to ligation and division of the pancreatic ducts. In the second place, such changes did not develop in these animals when lecithin was included in the diet, or when the ducts were merely divided and ligated and the pancreas was left in situ. These findings seem to corroborate the demonstration by Dragstedt and his co-workers^{115, 116} of a pancreatic hormone which is able to take over the function hitherto assigned exclusively to the external secretion of the pancreas. On the basis of our experimental observations, it may be said that in malignancy of the ampullar and periampullar regions radical surgery which does not involve excision of the pancreatic tissue may safely be done without reimplantation of the pancreatic ducts, but that lecithin, choline, pancreatic substance, or alcoholic extracts of the pancreas must be administered to forestall fatty changes in the liver when the operation includes excision of the head or of the head and body of the pancreas.

COMPLICATIONS

Hebert¹¹⁷ has continued the experimental work of Mann and Bollman⁸ on the tendency of the jaundiced animal to develop peptic ulcers, particularly on the duodenal side. His studies show that in these animals the gastric acidity following test meals and the duodenal alkalinity are not materially altered, but that both the acidity and the amount of gastric secretion in the fasting stomach are decreased. There is also a reduction in the buffering capacity of the duodenal contents, which is still further reduced when ulceration is present. These findings, of course, can be applied to the human being only with many reservations, for man can live only a limited time with complete biliary obstruction, and unrelieved jaundice is rarely present for a sufficiently long time to permit comparison with experimental animals.

There is a significant and increasing emphasis in the literature on the factor of hepatic insufficiency in jaundice. Heyd,¹¹⁸ who was the first to develop this association, naturally stresses it particularly, though he is careful to point out that it is merely frequent and not inevitable. Many writers now tend to emphasize the fact that hepatic dysfunction is more important than demonstrable morphologic hepatic change. It seems reasonable to believe, as Garlock¹¹⁹ has postulated, that whether or not the clinical picture of hepatic insufficiency be supported by the morphologic evidence of liver damage at autopsy, there is present some functional, intracellular hepatic derangement, with associated toxic and functional renal impairment, which is fundamentally responsible for the clinical syndrome. Our personal (unpublished) studies with chloroform and carbon tetrachloride necrosis of the liver furnish some support for this point of view.

The problem of renal dysfunction in jaundice, whether per se or as a part of hepatic insufficiency, is also attracting increasing attention. Thus Meyers, Brines and Juliar,¹²⁰ in a study of 21 fatal cases of jaundice, found 7 cases with a nitrogen retention above 50 c.c. per 100 mg. of blood, though in only 2 instances was sufficient renal pathology demonstrable to account for the laboratory findings. The logical explanation in at least some of the remaining cases seemed to be that the degenerating products of liver necrosis and insufficiency were responsible for the inhibition of renal function, the lesion being so acute and therefore so brief that structural alterations had no time to manifest themselves.

Elson¹²¹ studied 16 patients with obstructive jaundice who presented signs of renal damage, chiefly a reduced urea clearance and an excessive excretion of casts, epithelial cells, and leucocytes, without marked hematuria and albuminuria. As the jaundice subsided, the evidences of renal injury entirely disappeared. The author points out the extreme importance of these danger signals of renal dysfunction if surgery is to be undertaken. A similar warning was issued by Wilensky and Colp¹²² some years earlier, to the effect that the patient with diminished renal function is a poor risk for biliary surgery. Jones¹²³ repeatedly has emphasized the importance of the renal factor in hepatic disease, as well as the prognostic value of the presence or absence of spontaneous diuresis in both the jaundiced and the nonjaundiced patient.

The explanation of this type of renal function, which must be sharply distinguished from the bile nephrosis frequent in jaundiced patients, is not yet clear. In our own experimental work on the liver-kidney syndrome¹¹ we have been able to reproduce the deferred uremic death by the release of an artificially created biliary obstruction; the blood nitrogen values ranged as high as 171 mg. per 100 c.c. of blood. In another group of experiments¹²⁴ the intravenous and intraperitoneal injection of saline and aqueous extracts made from the livers of patients

who had died hyperpyrexia liver deaths caused elevations of nitrogen retention, which in some cases ranged to 181 mg. per 100 c.c. of blood. In the animals which recovered, the values fell to normal. Post-mortem study of both the animals which died and those which were sacrificed showed various degrees of liver changes in them all, associated with degenerative changes in the convoluted tubules of the kidneys, and mild hyperemia and avascular swelling of the glomeruli.

All these changes indicate the action of a powerful toxic agent. We¹²⁵ have shown in a series of personal experiments that the lining cells of the biliary ducts play no part in their production. Hans Meyer, quoted by Henschen,^{13, 14} suggests that the liver may furnish a urine-driving hormone, and Glauback and Molitor, also quoted by Henschen, report the relief of experimental anuria by the injection of a liver-extracted fraction. It would be tempting to accept these explanations, but the evidence is far from conclusive. The most reasonable explanation is that offered by Bruhl and Watzadse and quoted by Vaccaro,¹²⁶ to the effect that a diminished glycine synthesis in the liver is the fundamental cause of the oliguria, passing over into anuria, which is characteristic of this syndrome. Such an explanation, it should be noted, would indicate that the kidney damage is not associated with jaundice per se, but with the underlying hepatic dysfunction.

MORTALITY AND PROGNOSIS

It is generally granted that the mortality of jaundiced patients is considerably higher than that of nonjaundiced patients, but otherwise there is no very general agreement about results. Lee and Totten¹²⁷ consider the prognosis of common duct malignancy more favorable than the prognosis of other malignancies of the gastrointestinal tract because of the early appearance of jaundice. But their qualification, "except for the complications and duration of the jaundice," partially invalidates the rather optimistic outlook. Furthermore, as Lampert¹²⁸ pointed out in a discussion of carcinoma of the hepatic duct, to which the same guarded optimism is sometimes applied, malignancy of the biliary ducts often presents insuperable technical problems, quite aside from the fact that in cancer even early symptoms are late symptoms.

Best and Hicken,¹²⁹ in a discussion of the abnormally high death rate for short-circuiting operations in obstructive jaundice, conclude that an important cause is failure to determine the patency of the common duct before the type of surgery is decided upon. If its patency cannot be established by the probe or by cholangiography at the operating table, choledochostomy or choledochoduodenostomy, although technically more difficult, will give better final results and a lower mortality than cholecystostomy or gall-bladder intestinal anastomosis.

The average duration of life after a short-circuiting operation for malignancy is not more than seven or eight months, according to the

statistics of Clute,¹³⁰ of Eliason and Johnson,¹³¹ and of Rives, Romano, and Sandifer. Oppenheimer¹³² reports the survival of a patient with carcinoma of the head of the pancreas for twenty-nine months after cholecystgastrostomy, but this is most unusual; autopsy confirmed the diagnosis and revealed no metastases and no ascending infection, the usual causes of death in patients who survive the actual surgical act. Clute points out that, while exploration should never be omitted, the mere opening of the abdomen is attended with a very high mortality. Eliason and Johnson conclude that a normal life expectancy is possible in nonmalignant disease, but warn that the mortality from ascending infection is sufficiently high to make the indiscriminate performance of short-circuiting operations entirely unjustifiable.

Surgery for operative injuries of the common duct is always difficult and is attended with a rather high mortality, but the results may be excellent, as Lahey, Eliot, and others have shown. The mortality of surgery for uncomplicated stone in the common duct, although somewhat higher than for simple cholecystectomy, has been reduced to incredibly low figures in the hands of expert surgeons.

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Review of Recent Meetings

REVIEW OF THE TWENTY-FIRST ANNUAL MEETING OF THE AMERICAN SOCIETY FOR THORACIC SURGERY, ATLANTA, GA., APRIL 4-6, 1938

I. A. BIGGER, M.D., RICHMOND, VA.

(From the Department of Surgery, Medical College of Virginia)

DR. STUART HARRINGTON, Rochester, Minn., gave the presidential address on Hiatus Hernia of the Diaphragm. He showed some excellent anatomic sections made with especial elastic tissue stains, illustrating the weakening of the elastic fibers in the gastrophrenic ligament in patients with hernia. He gave a number of reasons for his preference for the abdominal approach; among these were: (1) there was less chance of postoperative pulmonary complications; (2) it was much easier to expose and repair a hernia projecting through the diaphragm on both sides of the esophagus or projecting through posterior to the lower end of the esophagus; and (3) the attachment of the hernial sac to the stomach could be separated only when the operation was carried out through this approach. In 21 cases in which the major operation did not seem advisable, phrenic interruption was done; only 5 of these patients failed to receive any relief. He showed an excellent motion picture of the technique of the trans-abdominal operation.

Dr. Joseph Weinberg, of Omaha, Neb., read a paper on the treatment of acute empyema thoracis by open intercostal drainage. He reported 53 consecutive cases operated upon by this method without a death. The operation is carried out in adults under local anesthesia and in children under cyclopropane. The intercostal muscles, the pleura, and the muscles of the chest wall overlying the intercostal space, usually the eighth posterolaterally, are excised for a distance of 5 to 8 cm. The opening is temporarily blocked with a piece of rubber dam packed with gauze, so as to permit the escape of pus, but at the same time to prevent the entrance of air into the pleural cavity. This tampon is removed at the end of forty-eight hours and irrigations are begun. He avoids the use of small pieces of gauze and short tubes for fear they will be lost in the cavity. He feels that irritation of the lungs by stiff rubber tubes may be one of the causes of the spread of infection by infected emboli. In patients under 16 years of age, the average postoperative convalescence period was twenty-one days, and in those over 16 years it was fifty days. He emphasized the importance of waiting until the fluid becomes definitely purulent before establishing this type of drainage.

Dr. I. A. Bigger, Richmond, Va., reported 17 patients with heart wounds operated upon in the Medical College of Virginia Hospitals during the past eight years and discussed the treatment and prognosis of heart wounds in general. He

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suggested that these patients be divided into four groups, depending upon whether the hemorrhage into the pleural cavity or tamponade predominated in the picture and also upon the degree of hemorrhage and the degree of tamponade. He advised immediate operation when there was massive hemorrhage into the pleural cavity and when there was tamponade with persistent circulatory collapse. Conservative treatment was advised in those patients with only moderate hemorrhage into the pleural cavity and aspiration of the pericardium in those with tamponade, but with a rise in the systolic blood pressure to near normal after the administration of fluids, adrenalin, etc.

He compared the recovery rates as estimated by the collection of cases from the literature with those collected by a questionnaire sent to the members of the American Association for Thoracic Surgery, the American Surgical Association, and the Southern Surgical Association. The latter figures showed a recovery rate of approximately 50 per cent, which was presumably a more accurate index of the chances of recovery from a heart wound than the figures obtained from the current literature.

In discussing this paper, Dr. Alfred Blalock, Nashville, Tenn., emphasized the importance of venous pressure determinations in the diagnosis of the condition. He also advised against prolonged delay before operation because of the danger of circulatory collapse. Dr. D. C. Elkin, Atlanta, Ga., doubted the wisdom of conservative treatment in patients with heart wounds, even when the blood pressure and pulse returned to a relatively normal level following conservative treatment, and reported one patient in whom conservative treatment was carried out. The patient at first had signs of a moderate tamponade which gradually improved, but, on about the sixteenth day after admission, the child developed signs of severe tamponade and died, apparently from secondary hemorrhage into the pericardium.

Dr. W. E. Adams and (by invitation) Dr. Dallas B. Phemister, Chicago, Ill., made a report on some experimental work on resection of the lower end of the esophagus and anastomosis with the stomach above the diaphragm. Sixty-one dogs were used and in 32 of them an anastomosis of the stomach with the esophagus was performed after resection of varying lengths of the lower esophagus. In 13 of these the anastomosis was made after the stomach had been brought up through a new opening in the diaphragm and in 19 the stomach was brought above the diaphragm through an enlarged hiatus. In 2 instances a continuous suture was used for the anastomosis and both dogs developed stenosis at the suture line. In 15 dogs the entire esophagus was mobilized and brought out through a cervical incision. All of these died in from two to eight days. In 14 dogs short segments of the thoracic esophagus were resected and the dogs were fed through a gastrostomy tube. Only very high resections were tolerated.

They reported a successful resection of the lower end of the esophagus in a 53-year-old woman with a carcinoma of the cardiac end of the esophagus. A transthoracic approach was used; the cardiac end of the stomach and the lower end of the esophagus were resected, the opening in the stomach closed, and the lower end of the esophagus anastomosed with the fundus of the stomach above the diaphragm. The left thoracic cavity was drained by one catheter. The patient made a relatively uneventful recovery.

Dr. Carl Eggers, New York, N. Y., read a paper on Upper Esophagostomy: Its Indications and Uses. He stated that gastrostomy should always be done as a preliminary procedure. At the time of the gastrostomy he advises dividing the

upper end of the esophagus and implanting the distal end of the upper segment beneath the skin near the left sternoclavicular junction. The upper end of the distal segment is closed by inversion and dropped back into the thorax and the resection carried out at a later stage.

In discussing Dr. Adams' and Dr. Eggers' papers, Dr. Edward D. Churchill, Boston, Mass., Dr. W. D. Andrus, New York, N. Y., and Dr. Harold Brunn, San Francisco, Calif., also advised doing a laparotomy first in lesions near the cardia to be sure that there were no metastases. Dr. Richard Overholt, Boston, Mass., advised against gastrostomy in the lower esophageal lesions because of fixation of the stomach resulting from this operation. Dr. Franz Torek, Montclair, N. J., stated that he did not believe that esophagogastronomy was feasible in most esophageal tumors because they are located too high within the thorax. Dr. Adams stated that a satisfactory exposure and exploration of the abdomen could be had through the diaphragmatic incision.

Dr. Evarts Graham and (by invitation) Dr. Brian Blades, St. Louis, Mo., reported upon 52 mediastinal tumors studied in the Washington University Clinic. In only 23 was operation attempted. Forty per cent of the entire group were of lymphatic origin; 11.5 per cent arose from nerve tissue; and 23 per cent were teratomas or dermoids. About 4 per cent were sarcomas from other than lymphatic tissue. Five of the teratomas were malignant and inoperable. A sixth one recurred after operation. Six were benign. Dr. Graham emphasized the importance of operating upon teratomas and dermoids early because of the danger of the development of malignancy or infection. Operation is frequently delayed because both physicians and laymen believe that the mortality rate in operation on such tumors is extremely high. He stated that the mortality rate in operation for benign tumors is approximately 7 per cent, while the chances of the development of malignancy are about 66 per cent. If there is doubt as to the diagnosis or the type of tumor, roentgen ray therapy should be tried. If the tumor is of lymphatic origin, it will shrink rapidly following such treatment; whereas, teratomas and dermoids do not show an appreciable response.

He advised intratracheal cyclopropane anesthesia and in most instances approaches the tumors through an anterior intercostal incision. In female patients this incision is made below the breast and when the operation is carried out in this way without the removal of cartilages the scarring is practically imperceptible. When the tumor is definitely in the posterior mediastinum, a posterior approach is used.

Dr. Blades stated that the anterior approach was followed by very slight pain and the convalescence was short (three to four weeks). He advised aspirating the pleural cavity on the first and second postoperative days.

Dr. John C. Jones, Los Angeles, Calif., and Dr. Harold Brunn, San Francisco, Calif., reported substernal thyroids which had been mistaken for dermoids. Dr. Edward D. Churchill, Boston, Mass., stated that the fear of chest deformity following thoracic operations was the result of the large number of chronic empyemas operated upon following the War period.

Dr. J. Samuel Binkley, New York, N. Y. (by invitation), discussed Aspiration Biopsy of the Lung as done at the Memorial Hospital in New York. The aspiration is done with the patient in the upright position. An 18 caliber needle is used and the material obtained is immediately smeared on a slide and stained. Ninety-two aspiration biopsies of the thorax have been done in this hospital during the

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of the ribs may be stripped through anterior incisions as far back as the rib angles. Short segments are removed anteriorly and about two weeks later through a 10 cm. posterior incision the superior rib borders are stripped and the ribs removed. At the same time the ribs below those removed are divided posteriorly so that they can be removed at the third stage through an anterior incision. He has found it possible by this method to obliterate total empyema cavities completely by a three-stage operation. In some of the very large empyema cavities there has been a small residual cavity posteriorly necessitating excision of parietal pleura.

In his more recent technique the greater portion of the operation is carried out from in front. With development and employment of sharp periosteal separators, the rib may be removed from either direction, granted that it is divided on the other end. If a rib is divided near the sternum, it may be completely removed through a posterior incision; if a paravertebral segment of the rib as far as its angle be removed through a posterior incision, the remainder of the rib may then be removed with ease through an anterior incision. This method of rib removal is particularly applicable in the performance of thoracoplasty for tuberculosis as well as for chronic empyema. If apicolysis is to be done at the time of thoracoplasty for tuberculosis, it is carried out from in front, the apex of the lung is stripped downward as far as is indicated and fastened down by broad bands of catgut, such as are used by urologists to suspend kidneys.

Dr. Joseph W. Gale and (by invitation) Dr. W. H. Oatway, Jr., Madison, Wis., discussed the results and complications of the Semb type of apicolysis carried out in conjunction with thoracoplasty. Dr. Gale removes from two to four ribs at one time and does an apicolysis down to the upper intact rib. He then sutures the posterior ends of the intercostal muscles to the neck of the first intact rib posteriorly to keep the apex of the lung down. He uses cyclopropane anesthesia and states that a relatively deep anesthesia is necessary for the operation.

This operation has been carried out in the University of Wisconsin Clinic in 102 cases over a two-year period. Thirteen of these patients were more than 45 years of age. There was some involvement in the contralateral lung in 84 per cent of them and there were advanced lesions in the contralateral lung in 24 per cent. He suggests that both the pre- and postoperative administration of opium be reduced to a minimum and that oxygen therapy be continued as long as there is evidence of anoxemia. The chief complication has been atelectasis which frequently comes on after apicolysis. He advises clearing the bronchial tree in wet cases. Atelectasis may be treated by bronchoscopic aspiration.

An effective collapse was obtained in 77 per cent of the cases. There were 14 deaths in the group, or a mortality rate of 13.7 per cent. He believes that the ideal cases for the Semb operation are those patients in good condition with a good contralateral lung, in whom other systemic complications are absent and where the cavity is large, thin-walled, and easily collapsible. The use of apicolysis in an unselected group allowed the authors to derive the first tentative indications for the operation. They conclude that in repeating the same cases they would decrease the extent of lysis in 40 per cent of the cases and not do a lysis in another 20 per cent.

Dr. Ethan Flagg Butler, Ithaca, N. Y., described Myoplastic Thoracoplasty. The operation is indicated especially in large anterior apical cavities and is carried out through an anterolateral incision, extending from the midclavicle to the anterior axillary line at the level of the fourth interspace, and thence downward an additional three inches. The insertions of both pectoral muscles are

past ten years. In 56 cases of bronchogenic carcinoma there were 80 per cent positive biopsies by aspiration, while there were 57.1 per cent bronchoscopic failures as proved by aspiration biopsies.

In discussing Dr. Binkley's paper, Dr. J. J. Singer, Los Angeles, Calif., and Dr. Ralph B. Bettman, Chicago, Ill., warned of the dangers of pneumothorax, empyema, and embolism. Dr. Singer advocated artificial pneumothorax followed by thoracoscopic examination and biopsy. Dr. D. C. Elkin, Atlanta, Ga., stressed the importance of a positive diagnosis in suspected carcinoma of the lung, for otherwise the patients would not submit to operation.

Dr. William M. Tuttle and (by invitation) Dr. J. P. O'Connor, Detroit, Mich., discussed extrapleural thoracoplasty in the presence of contralateral pneumothorax. Eighty-six patients who had pneumothorax on one side were subjected to thoracoplasty on the contralateral side. Fifty-one of these showed cavitation; in 18 the cavities remained open, but in 69 per cent they were closed following thoracoplasty. Twenty-seven of these patients still have a pneumothorax. The mortality rate was 21.1 per cent; 9.4 per cent died shortly after operation and in 11.7 per cent death occurred late. Twenty-two per cent of the patients showed arrest of the disease.

Dr. Pol N. Coryllos and Dr. G. G. Ornstein, New York, N. Y., discussed Tension (Giant) Tuberculous Cavities; Pathogenesis, Mechanics, and Surgical Management. Dr. Coryllos stated that these large round cavities contain air under positive pressure with a higher percentage of oxygen and less carbon dioxide than alveolar air. He showed diagrams illustrating the effects produced by varying degrees of bronchial stenosis. In moderate stenosis the air passes both ways relatively freely. In more advanced stenosis air is able to enter the cavity on inspiration, but part of it is trapped on expiration, thus producing a constant positive pressure within the cavity, thereby causing it to enlarge rapidly. In complete stenosis atelectasis results. These authors have demonstrated by gas analysis and by the injection of lipiodol directly into the cavity through the chest wall that there is a communication with the bronchial tree in these cases. The trapping of air in the cavity and the production of a positive pressure produce a vicious cycle, and reduction of the pressure within the cavity by aspiration of air may control this vicious cycle and allow air to escape on expiration.

Dr. Coryllos believes that the only cure for such cavities is obliteration of the bronchial opening by the application of sclerosing substances or by muscle transplants. He stated that the experiments so far have not been productive of positive results but have opened up an interesting problem for further investigation.

Dr. Jerome R. Head, Chicago, Ill., described a multiple stage muscle-splitting operation for extrapleural thoracoplasty which he had done first in 1929 but had then abandoned. More recently he had again begun doing this type of procedure because it reduces shock and infection to a minimum and decreases paradoxical respiration. It also preserves the muscles of the shoulder girdle. It is carried out in six stages, three posteriorly and three anteriorly. Most of the rib stripping is done subcutaneously by an especially constructed periosteotome. The periosteum of the upper six ribs posteriorly is destroyed. Apicolysis may be done in conjunction with the upper posterior stage.

Dr. Owen H. Wangensteen, Minneapolis, Minn., also discussed a method for doing thoracoplasty through short incisions. The operation is done through short anterior and posterior incisions, which depended initially upon the direction and insertion of the external intercostal muscle bundles. The lower borders

Careful hemostasis is required and it is, of course, necessary to make an airtight closure. Frequent refills are necessary in the early stages, two a day for the first few days, but eventually only one refill every two or three weeks will be needed. It is necessary at first to maintain a positive pressure of 10 to 20 cm. of water.

Serosanguineous effusion occurred in practically all cases. This should be aspirated. In one instance infection developed in this fluid and the cavity had to be drained. One patient died from hemorrhage. The temporary results were satisfactory in most instances. It is not to be used when thoracoplasty is suitable. The pleura is usually stripped down to the level of the seventh or eighth rib posteriorly. The most common complications are serosanguineous effusion, injury to the pleura, emphysema, and hemorrhage. Infection is apt to be serious.

This paper was discussed by **Dr. Churchill**, who stated that he felt that the procedure was of value, but that he wished to emphasize that it was more dangerous than thoracoplasty. **Dr. John C. Jones**, Los Angeles, Calif., emphasized the absence of deformity following extrapleural pneumothorax in young children. **Dr. Coryllos** insisted that the operation should be called pleurolysis and said that it was not a satisfactory procedure where there was fibrosis. He felt that it was a suitable procedure for cases with bilateral disease where thoracoplasty was contraindicated. He does the operation under local anesthesia and uses a Cameron light for better vision. He uses small sponges soaked in novocain and adrenalin with which to strip the pleura.

Dr. John C. Jones, Los Angeles, Calif., discussed the indications and contraindications for lobectomy and pneumonectomy in pulmonary tuberculosis. He reported four cases in which such procedures had been carried out. The first one, a man, had the right upper and middle lobes removed for uncontrollable hemorrhage. Thoracoplasty was done later for obliteration of the cavity. The second patient, a 28-year-old woman, had stenosis of the left main bronchus with severe bronchiectasis distal to it, for which pneumonectomy was done. There was a persistent bronchial fistula. Eight weeks after the pneumonectomy she developed an exudative lesion in the right lung, but this is now apparently improving. The third case, a 29-year-old female with a large apical cavity, had had an extensive thoracoplasty in 1936, but without obliteration of the cavity. There was no evidence of tracheobronchial tuberculosis. The upper lobe was removed and there was demonstrated a 2½ cm. residual tuberculous cavity. She developed a bronchial fistula which has now practically healed over. The fourth case, a 49-year-old woman, had a lesion of the right lower lobe which was thought to be malignant. Pneumonectomy was done through the anterior approach and there was a relatively uneventful convalescence.

The indications for lobectomy or pneumonectomy are: (1) failure to respond to other procedures; (2) persistent hemorrhage; (3) suppurative lung disease and tuberculosis in the presence or absence of bronchial occlusion; (4) persistent cavitation after complete thoracoplasty; (5) atelectatic honeycombed lobe after complete thoracoplasty; and (6) basal cavities which fail to heal after the usual procedures.

In discussing this paper, **Dr. Evarts Graham**, St. Louis, Mo., recalled that Tullier removed a portion of the right lung and found it to be tuberculous approximately fifty years ago. He (Dr. Graham) had done two lobectomies to arrest hemorrhage and three others for calcified lesions which were in all probability tuberculous in origin and one other lobectomy for what was thought to be a tumor but which proved to be a tuberculoma. He emphasized the impor-

divided. The first rib may be left in place, but the second and third ribs are removed from sternum to vertebral bodies. The apex of the lung is stripped down to the desired level and the pectoral muscles are swung across above the lung and sutured to the posterior wall so as to form a muscle diaphragm for holding the lung down.

The operation has been carried out in 10 cases with 2 deaths, one from a spontaneous pneumothorax in the other lung and the second from the late effects of wound infection attributable to a pre-existing mixed infection empyema. Of the 10 cases, 3 have shown entirely satisfactory results, 1 is questionable, and 4 have been unsatisfactory. Dr. Butler now thinks that it is probably better to remove the first rib to avoid the formation of a dead space.

In the discussion of this group of papers on pulmonary tuberculosis, Dr. Edward S. Welles, Saranac, N. Y., raised the question as to whether there might be lymphatic blockage of the breast following Dr. Butler's operation. He reminded the audience that Dr. Archibald had used a muscle flap in his apicolysis but had given it up because of the marked degree of muscle atrophy which followed. He advised against using the Semb operation as a routine procedure and stressed the importance of better x-ray plates, particularly the importance of overexposure of the involved side in an attempt to demonstrate residual cavities in a collapsed lung.

Dr. Cameron Haight, Ann Arbor, Mich., stated that they were no longer using the Alexander type of muscle transplant to the apex. He also said that they had given up cavity drainage in large tuberculous cavities. Dr. J. J. Singer, Los Angeles, Calif., called attention to bronchiectasis in association with pulmonary tuberculosis as being one of the causes of failure of thoracoplasty. Dr. Warriner Woodruff, Saranac, N. Y., also called attention to the dangers of the Semb operation and warned against its too frequent use. He had found that it increased the occurrence of atelectasis and also increased the chances of tuberculous infection of thoracoplasty wounds, probably due to the division of infected mediastinal lymph channels during the dissection. Dr. Richard Overholt, Boston, Mass., expressed disappointment at the results obtained by apicolysis but stated that he felt that it was of some value. He still favors the large posterior incision because he feels that shock is not due to the amount of muscle and skin severed but primarily to the amount of rib removed, and to control this he advises waiting a sufficient time between stages. Dr. Pol N. Coryllos, New York, N. Y., pointed out the trend toward complete selective collapse, especially in bilateral cases. He stated that paralysis of the diaphragm increased the chances of atelectasis, a condition which should always be kept in mind and treated by aspiration when it occurred. Dr. Joseph Gale, Madison, Wis., emphasized the importance of post-operative compression of the chest by the John Steel type of brace. Dr. Butler advised doing wet cases in the afternoon, to give them a chance to clear the cavities out during the morning.

Dr. Ronald Belsey, London, England (by invitation), introduced by Mr. J. E. H. Roberts, London, England, and Dr. Edward D. Churchill, Boston, Mass., discussed Extrapleural Pneumothorax, a procedure introduced by Graf and first tried by Roberts in 1935. It apparently is indicated in patients in whom thoracoplasty would be desirable but for certain reasons is contraindicated. The operation is carried out under cyclopropane anesthesia and an incision is made over the fourth rib centering over its angle. The rib is resected posteriorly as far as the transverse process; the pleura is then exposed and separated from the chest wall by careful dissection until a sufficient amount is free to give the desired collapse.

fistulas lead to empyema. There are no symptoms if the fistula is small, and it can be detected only by gas analysis. He accounted for his low rate of fistulas with the Jacobaeus operation by stating that he worked only in the parietal subpleural space.

Dr. Alton Ochsner and (by invitation) **Dr. Michael DeBakey**, New Orleans, La., described **The Operative Correction of Pectus Excavatum**. It is usually congenital, consisting of depression of the sternum and costal cartilages, and is not due to rickets. It occurs four times as frequently in men as in women. The various causes to which it is attributed are that it runs in families, is due to growth disturbances, perhaps is due to pituitary influence, is due to mediastinitis, with resulting inward pull on the sternum. Few cases are due to acute trauma, occupation (as cobbler's disease), or poor posture.

It is characterized by depression and rotation of the sternum, a decrease in the anteroposterior thoracic diameter, and an increase in the transverse diameter. The heart is displaced usually to the left, with rotation and compression. The lungs may be compressed, as may the esophagus; and the diaphragm is depressed. Signs and symptoms may be absent. If present, they consist of: (1) cardiac: dyspnea, palpitation, pain, and decompensation; (2) pulmonary: dyspnea, cyanosis, cough, reduction in vital capacity; also dysphagia and dyspepsia; the patients are weak, asthenic, and debilitated. It is to be differentiated from rickets. Complications include myocarditis, bronchitis, and tuberculosis.

The treatment may be conservative, such as breathing, posture, and orthopedic exercises. Three types of operation have been used: (1) chondrosternal resection (10 cases with 2 deaths); (2) T-sternotomy with splitting of the sternum and some sort of wedging apart of the sternal segments (14 cases done, with 8 cures, 4 deaths, and 2 failures); (3) sternal mobilization with chondral resection (8 cases done, with 7 cures and 1 failure). The operation is done only for marked symptoms and disability. Dr. Ochsner reported a case in which he had done the latter type of operation through elliptical incisions, freed and elevated the sternum over a Parham band, which he attached to an anterior plaster shell. The result was quite satisfactory.

In discussion, **Dr. Jerome Head**, Chicago, Ill., reported two cases operated upon, with one death, and said that symptoms may be present even if the heart can escape to the left. **Dr. James C. Sandison**, Atlanta, Ga., reported two cases, one in which he used a sternal bone (tibial) wedge, and the other, a Parham band, which he advised not putting too high. Dr. Ochsner said that he would use two Parham bands instead of one on his next case.

Dr. John V. Bohrer and (by invitation) **Dr. Charles W. Lester**, New York, N. Y., discussed **Late Results of Lobectomy for Bronchiectasis in Children**. They made a careful survey of the 4 cases reported before the American Association for Thoracic Surgery in 1934 and added 6 cases operated upon since that time. Eight of the 10 cases recovered and are now in good general health. The authors pointed out the fact that these patients had been operated upon during the past nine years and for this reason the mortality rate was higher than would be likely at present because of the important recent improvements in the technique of the operation. One patient was subjected to a single stage pneumonectomy; 2 had complete pneumonectomies done in two stages (the lower lobe being removed first); the right middle, and lower lobes were removed in 1 case; and 6 had single lobes removed.

Where all of the diseased tissue was removed, cure has been complete. In those patients with slight involvement of the upper lobe at the time of removal

tance of not attempting to develop this phase of tuberculosis surgery too rapidly. Dr. Robert Glen Urquhart, Norwich, Conn., felt that tuberculous stenosis of the bronchus was a sound indication for pneumonectomy.

Dr. H. McLeod Riggins, New York, N. Y., discussed **Tuberculosis of the Bronchi Complicating Pulmonary Tuberculosis: Its Effect Upon Closure of Pulmonary Cavity**. He stated that tuberculous endobronchitis secondary to pulmonary tuberculosis was a serious complication, making the patient a poor surgical risk and increasing the danger of emphysema and atelectasis. He classified these lesions as: (1) catarrhal, (2) ulcerative, (3) hyperplastic, and (4) fibrostenotic. The bronchial lesion interferes with the ability of the lung to eliminate secretions and also increases the pressure within the lung, thereby causing an increase in the size of cavities. He stated that the bacterial flora within the bronchi altered the clinical picture. The recommended treatments have been: (1) postural drainage, which is of questionable value; (2) pneumothorax, which is distinctly dangerous; (3) bronchoscopic treatments, which are valuable especially when used in conjunction with silver nitrate, the electric cautery, and ionization. In his group of patients, 30 per cent were worse, 45 per cent were improved, 8 per cent healed, 4 per cent unknown, and 11.7 per cent dead.

Dr. J. J. Singer, Los Angeles, Calif., in discussing this paper, stated that many patients who were repeatedly bronchoscoped felt better afterwards, but after a time this was dependent not so much upon the drainage as upon the repeated use of cocaine. He felt that bronchoscopic drainage was palliative at best and urged earlier resort to surgery.

Dr. Oscar Auerbach, New York, N. Y., read a paper on **Bronchopleural Fistulas Complicating Pulmonary Tuberculosis: A Clinical Pathological Study**. He stated that it was the commonest cause of infection of the pleura. Out of 1,000 cases of fibroulcerative tuberculosis, 78 patients developed bronchopleural fistulas; 67 of them had single fistulas, and 11 had multiple fistulas. He classified them as: (1) fistulas without pre-existing pneumothorax, which are usually fatal; (2) fistulas complicating artificial pneumothorax; many of these patients survive and they account for 70 per cent of his series; (3) fistulas developing after internal pneumolysis operations (tuberculous caseation, excavation, on to fistula formation). The second group occurs from two to six months to four years after the institution of pneumothorax; they are caused by the liquefaction of small caseous foci or cavities communicating with a bronchus and breaking through into the pleura. They are apt to follow collapse of acute exudative lesions, so this may be considered a serious contraindication to collapse in this type of case, as the collapse seems to increase the chances of certain areas' sloughing out, thus leading to fistula formation. The third group (after the Jacobus operation) accounted for 1.25 per cent of Dr. Coryllos' series.

Adhesions which may be cut are of three types: (1) fibrous (hyalinized connective tissue), which are safe to cut; (2) round bands, often containing lung tissue; and (3) fanlike bands, always containing lung tissue. When lung tissue is cut, necrosis ensues and empyema develops.

Healing in fistulas may occur spontaneously, due to obliteration by thick pleura. The pleural layers may stick together or exudate may seal the fistula and form a fibrous scar. The temporary closure often occurs due to fibrinous plugs. The size of the fistulas varies from 1.0 mm. to 4.0 cm. Sixty per cent are in the upper lobes.

In discussion Dr. Coryllos said that bronchopleural fistula was rare without pneumothorax because of the protection afforded by pleural adhesions. All

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ATLANTIC CITY, N. J., MAY 2, 1938

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of the lower lobe, the disease has progressed, necessitating removal of the upper lobe. Even following complete pneumonectomy there has not been any appreciable deformity. The authors conclude that extirpation of the diseased lung tissue is the only means of curing bronchiectasis.

Dr. Edward D. Churchill, Boston, Mass., said that lobectomy really cures children even if they do not appear sick, and many bronchiectatic children on sound regimes do not look sick. The disease must be proved by lipiodol. It progresses very slowly. Fibrosis and emphysema occur in the good portions of the lung from constant infection.

Dr. Minas Joannides, Chicago, Ill., spoke on the Mechanics of Pulmonary Abscess and Bronchiectasis with Suggested Method of Treatment. He stated that abscess may follow pneumonia, trauma, aspiration, embolus (which causes infarct); and the organisms are fusiform bacilli, spirochetes, and diphtheroids. Infection is facilitated when blood is present in the bronchial tree. The course is broadly the same as infection and abscess formation in other tissues. Hyperemia, stasis, exudation go on; the abscess forms under the condition of low oxygen tension. The treatment is oral hygiene, postural drainage, x-ray and bacterial study, arsphenamine, and increased moisture in the air in the room, including gomenol in the steam. This causes hyperemia, increase in sputum, and increased coughing and removal of exudate. (This may be overdone and may produce pulmonary edema.)

Dr. Joannides stressed the importance of early differentiation of ordinary pneumonia and the pneumonitis which precedes abscess. He said that fusospirochetes should always be looked for in the sputum. Proper treatment in this stage will likely abort the infection. Neo- or sulpharsphenamine in 0.3 to 0.6 gm. every two or three days is a great aid. Artificial pneumothorax is definitely contraindicated, as it promotes atelectasis and produces a spread of the infection.

In discussion, Dr. Joseph Weinberg, Omaha, Neb., said that the mechanism of infection was much more important than the organisms, that treatment varied with the organisms, and that iodized oils should not be used. Dr. Jerome R. Head, Chicago, Ill., said that fusospirochetes were seen only in poor patients; such patients get intoxicated (to the point of anesthesia) and aspirate from dirty teeth and gums. Ninety per cent of these abscesses are located posterior to and below the spinal angle of the scapula. Dr. Ralph B. Bettman, Chicago, Ill., said that gentian violet put into the mouths of anesthetized dogs was always found in the lungs when the dogs were sacrificed.

Dr. Otto C. Pickhardt, Dr. William H. Stewart, and Dr. Grant Thorburn, New York, N. Y., showed some interesting moving pictures, *Cinefluoroscopic Studies of Peculiar Breathing and Chest Motion*, after phrenicotomy, thoracoplasty, pneumothorax, etc. This technique appears to have great possibilities for teaching.

I wish to express my appreciation to Dr. F. C. Fishback, Washington, D. C., for the use of his notes on the meeting in completing this report.

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John Russell Smith and William Bryan Kountz, of St. Louis, Mo., perfused cadavers immediately after death with oxygenated, defibrinated blood. With a constant arterial injection of 60 c.c. per minute, the blood pressure of normal subjects was found to be lower than the pressure observed in subjects which had exhibited arteriosclerosis or hypertension before death. Injection of pressor substances produced a marked increase in blood pressure in the hypertensive subjects, but in the arteriosclerotic group the rise was less than in the normals.

Eugene A. Stead, Jr., and Paul Kunkel, of Boston, Mass., described a plethysmographic method for the determination of the blood flow through the foot. At a temperature of 43° C., the average flow of blood was found to be 17 c.c. per minute per 100 c.c. foot volume, only one-half as great as that through the hand at the same temperature. In patients with asymptomatic obliterative vascular disease, the flow was reduced by 50 per cent. In patients with symptoms of vascular insufficiency the flow was reduced by more than 60 per cent. Vasomotor reactions were observed in the blood flow through the foot comparable to those observed in studies on the hand.

George P. Robb and Israel Steinberg, of New York, N. Y., detailed a practical and safe method of visualization of the chambers of the heart, the pulmonary circulation and the aorta in man. They injected 70 per cent diodrast into the arm vein with great rapidity and, by x-ray studies taken 1 to 2 seconds later, were able to outline the vena cava, right auricle, right ventricle, and pulmonary arteries. Eight to sixteen seconds later (the circulation time was measured by the cyanide method), they were able to outline the left ventricle and aorta. In over 100 injections, no serious mishaps were observed, although a fall in blood pressure and rise in heart rate were frequent, while chills or urticaria were observed in about 10 per cent of the cases.

Jerome W. Conn and L. H. Newburgh, of Ann Arbor, Mich., studied the carbohydrate metabolism in six cases of chronic infectious hepatitis. The characteristic findings in all the cases were a low fasting blood sugar and an inability to store carbohydrate. When deprived of carbohydrate in the diet for forty-eight hours, three of the patients went into hypoglycemic shock. All patients showed a diabetic type of sugar tolerance curve. The carbohydrate utilization, however, was unaffected. The essential feature appeared to be liver damage with consequent inability to store or release glycogen. Removal of a diseased gall bladder brought about complete return to normal function in two of the patients.

THE FIFTY-FOURTH MEETING OF THE AMERICAN ASSOCIATION OF ANATOMISTS, UNIVERSITY OF PITTSBURGH, PA., APRIL 14-16, 1938

EDWARD A. BOYDEN, PH.D., MINNEAPOLIS, MINN.

(From the University of Minnesota)

THIS meeting, held in conjunction with the American Association of Physical Anthropologists, was of special interest as marking the fiftieth anniversary of the founding of the Association, in recognition of which a limited issue of medallions of the first president, Joseph Leidy, of Philadelphia, had been modeled by the late Dr. Robert Tait McKenzie, distinguished American sculptor and former member of the Association.

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At the subscription dinner, further commemorating this anniversary, a telegram was received from President Roosevelt, following which official greetings from the Anatomical Society of Great Britain and Ireland were presented by Dr. John Beattie, Director of Research of the Royal College of Surgeons in London. Letters of felicitation, also, were read from every anatomical society in Europe. Incidentally, it was noted that the American society is one of the three oldest, having been organized less than a year after the British and German organizations. The rest of the evening was devoted to a scholarly presentation of the history of the American association by the retiring President, **Dr. Frederick T. Lewis**, of Harvard University. He divided the life span of the Society into three periods, the first of which, extending through the presidencies of Joseph Leidy, Harrison Allen, Thomas Dwight, Frank Baker, and Burt G. Wilder, was characterized by almost exclusive attention to gross anatomy as an adjunct of surgery. In the second period, under the influence of Huntington, Minot, and Mall, American anatomists entered upon active morphological research, participating especially in striking advances in the field of descriptive embryology. In the third period, initiated by Harrison's discovery of the method of tissue culture and continuing to the present time, the work of the Association has become predominantly experimental. Reminiscences of the first two periods were then given by former presidents of the Association, **Dr. J. P. McMurrich**, of Toronto, and **Dr. C. F. W. McClure**, of Princeton. Rising to a toast, **The Future of Anatomy**, former president **Herbert M. Evans**, of California, humorously remarked that, in consequence of the polygamous union of physiology with chemistry and physics, there had been delegated to anatomy the significant task of interpreting function in terms of structure.

The opening session, likewise striking a festival note, was given over to other past presidents of the Association: **R. G. Harrison**, of Yale, speaking on factors in the development of the ear; **R. R. Bensley**, of Chicago, on plasmosin, an important constituent of protoplasm; **C. M. Jackson**, of Minnesota, on the nature of the abnormally rapid increase in body weight following suppression of growth; **Florence R. Sabin**, of the Rockefeller Institute, on tuberculous allergy without infection; **G. L. Streeter**, of the Carnegie Institution, on the origin of gut endoderm in monkey embryos; and **C. R. Stockard**, of Cornell, on structural disharmony in the development of upper and lower jaws following extreme hybridization. The paper of **W. H. Lewis**, of Baltimore, illustrated by moving pictures of lymphocytes and monocytes in tissue cultures, was deferred until the last morning of the sessions.

On the second and third mornings, there were four round table discussions, all largely attended. The first, under the chairmanship of **Edgar Allen**, of Yale, attempted to cover the entire endocrine control of the female sexual and reproductive functions in monkeys and other primates. The second, under **A. W. Meyer**, of Stanford University, discussed some aspects of the pelvis and vertebral column. The third, under **J. C. Hinsey**, of Cornell, dealt with visceral afferent pathways and visceral sensation. The fourth, under **Hal Downey**, of Minnesota, restricted itself to the lymphocyte. Abstracts of these discussions will appear in the May number of *The Anatomical Record* (71: No. 1, 1938).

In conjunction with the anthropologists, several anatomists participated in a symposium on growth and at a joint evening session in the Mellon Institute, **Dr. Franz Weidenreich**, of Peiping Union Medical College, presented his striking studies on the thirty-eight specimens of *Sinanthropus Pekinensis*—an ancient race interpreted as antedating the "ape-man" of Java. In a final joint session, six subjects were discussed: the fixation of the facial skeleton to the cranial base (**W. M. Cobb**, of Harvard University); rare features in the tibia (**Aleš Hrdlička**,

of Washington, D. C.); body build and pelvic type in white women (W. W. Greulich, of Yale); calcification patterns of human deciduous teeth (I. Schour, of Illinois); regional trends in human malformations (W. F. Peterson, of Illinois); and the pigments and color of living human skin (E. A. Edwards, of Harvard).

The Friday afternoon session was devoted to the viewing of sixty-eight demonstrations, 9 of which required moving pictures.

In the remaining three half days, 170 short papers of 10-minute length were reported, these being classified approximately as follows: endocrinology, 51; neurology, 41; embryology, 26; histology and blood, 26; gross and comparative anatomy, 16; miscellaneous, 7. Abstracts of these may be seen in the March 25 number of *The Anatomical Record* (70: No. 4, Suppl. 3).

Officers elected for the ensuing two years or more are as follows: President, Stephen W. Ranson (Northwestern University); First Vice-President, T. Wingate Todd (Western Reserve University); Second Vice-President, Albert Kuntz (St. Louis University); Secretary-Treasurer, Eliot R. Clark (University of Pennsylvania); Executive Committee, George W. Corner (University of Rochester) and Olof Larsell (University of Oregon).

Book Reviews

Thoracic Surgery. By Ferdinand Sauerbruch and Laurence O'Shaughnessy. Cloth. Pp. 394, with 215 illustrations, and 15 full page plates in color. Baltimore, 1938, Wm. Wood and Company. \$13.50.

The volumes on thoracic surgery by Professor Sauerbruch have been admired and studied with care by thoracic surgeons everywhere. The appearance of this abridged "Sauerbruch" in English will be welcomed on every hand. The authors state in their preface that their chief aim in this volume is to reach an audience less directly concerned with the surgery of the thorax, viz.: "the general surgeon or physician, the tuberculosis specialist and more especially the general practitioner."

The entire subject of thoracic surgery is briefly reviewed in the pages of this monograph and the practices of the Sauerbruch clinic are described. A useful and up-to-date bibliography is appended containing a fairly large number of references to English and American contributions. The illustrations are excellent and the beautiful color plates add much to the book. One looks in vain through the text, however, for the name or names of the artists who have made so important a contribution to this work. The liberal use of illustrations by the authors indicates that they value highly the capacity of the eye to grasp situations which mere description cannot elucidate or define properly. It is not without interest that Andreas Vesalius in his *De Fabrica Humani Corporis* omitted to mention the name of his brilliant artist, Jan Stephan von Calcar, whose artistic creations added much to the "Fabrica"; yet posterity has rescued his memory from oblivion.

This reviewer was somewhat astonished to find the operation of posterior thoracoplasty described as being performed still from below upward. The reversal of this procedure by Alexander has met with such universal approbation by thoracic surgeons in this country that it seemed unlikely that the older sequence was still in use. In the light of the emphasis placed by the authors on the removal of the paravertebral segments of the ribs in thoracoplasty for tuberculosis, it is somewhat surprising to note in their illustrations (pages 190 and 192) how long the residual unresected paravertebral segments of the ribs are. In the treatment of empyema by intercostal drainage and suction, no mention is made of the importance of the admission of air to the pleural cavity or employment of irrigation to secure satisfactory drainage. In the recognition of wounds of the heart, the authors make no mention of the increased venous pressure and the use of the fluoroscope—the two agents of greatest value in detection of tamponade of the heart. The chapters on pulmonary suppuration, carcinoma of the lung, and malignancy of the esophagus are well done. The authors extol paraffin plombage for the treatment of certain types of pulmonary abscess. The historical aspects of each problem are related in sufficient detail to acquaint the reader properly with the advance in knowledge and accomplishment of each subject under consideration. The authors direct attention to the fact that all para-esophageal (hiatus) hernias described by the roentgenologist will not be found by the surgeon and urge caution in operating upon these unless some viscus other than the stomach is engaged in the sac. The text concludes with an appendix in which O'Shaughnessy's operation of cardio-omentopexy for cardiac ischemia is described.

This abridged "Sauerbruch" should prove eminently useful and should find favor amongst a wide audience of American readers.

The Roentgenologist in Court. By Samuel Wright Donaldson. Cloth. Pp. 230. Springfield, Ill., 1937, Charles C. Thomas, Publisher. \$4.00.

The author has presented the relationship of the physician and medical practice to the law in a manner which is authoritative and yet which makes enjoyable reading. The title is almost too exclusive considering the scope of the book. Although written expressly for the radiologist, it should be of interest to all practitioners of medicine.

It is unusual to review a book by citing the table of contents, but in this instance one can consider that each subject is adequately covered, and an index of its contents shows the wide interest it should have for all physicians.

Any physician may be called into court at any time to testify in a medicolegal proceeding. Because of this fact, the following chapters will be found to be of great interest: "Evidence and Testimony," "Privileged Communications," "Expert Testimony," "Expert Witness Fees," and "Doctor, Take the Stand."

Of importance to physicians in relation to their business arrangements with each other and with their hospitals is the discussion of physicians and contracts.

Other subjects of general interest are: "The Relationship Between Physician and Patient," "Malpractice," "The Physician and the Law of Agency," and "Malpractice Defense and Prophylaxis."

Primarily of interest to the roentgenologist are the chapters on "X-ray Films as Evidence," "Ownership of X-ray Films," and the introduction which deals with the legal question as to whether the practice of roentgenology is the practice of medicine.

A Practice of Orthopaedic Surgery. By T. P. McMurray. Pp. 471, with 178 illustrations. Baltimore, 1938, William Wood & Co. \$5.00.

The author presents a small but concise volume on the practice of orthopedic surgery. As such it is a worth-while addition to the library of the general practitioner and orthopedic surgeon, too. The general practitioner will find simply stated the various lesions commonly seen in orthopedic work and their more useful types of treatment. The orthopedic surgeon will find the viewpoint of an eminent orthopedic surgeon clearly expressed. The author's heritage is pre-eminent coming into the workshop of his predecessors, Hugh Owen Thomas and Sir Robert Jones, both of whom are usually regarded as the outstanding leaders of the medical profession toward the present methods used in orthopedic surgery.

One looking for minute detail of operative technique or treatment will be disappointed, for the detail is lacking. One looking for extensive discussion of controversial subjects will be disappointed because for the most part the author has given his views and left those of others alone.

The illustrations are perhaps too scanty, but for the most part they are clear and well chosen. The diagrams and drawings are a bit too simple perhaps, but again they fit in with the plan of the book. For one looking for a brief but concise treatise on orthopedics, the volume has much to recommend it.



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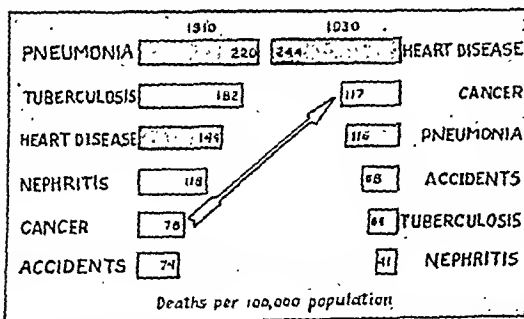
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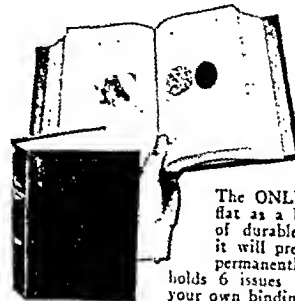
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The Johns Hopkins University and Hospital, Baltimore. 328 pages, 26 illustrations. PRICE, \$3.00.

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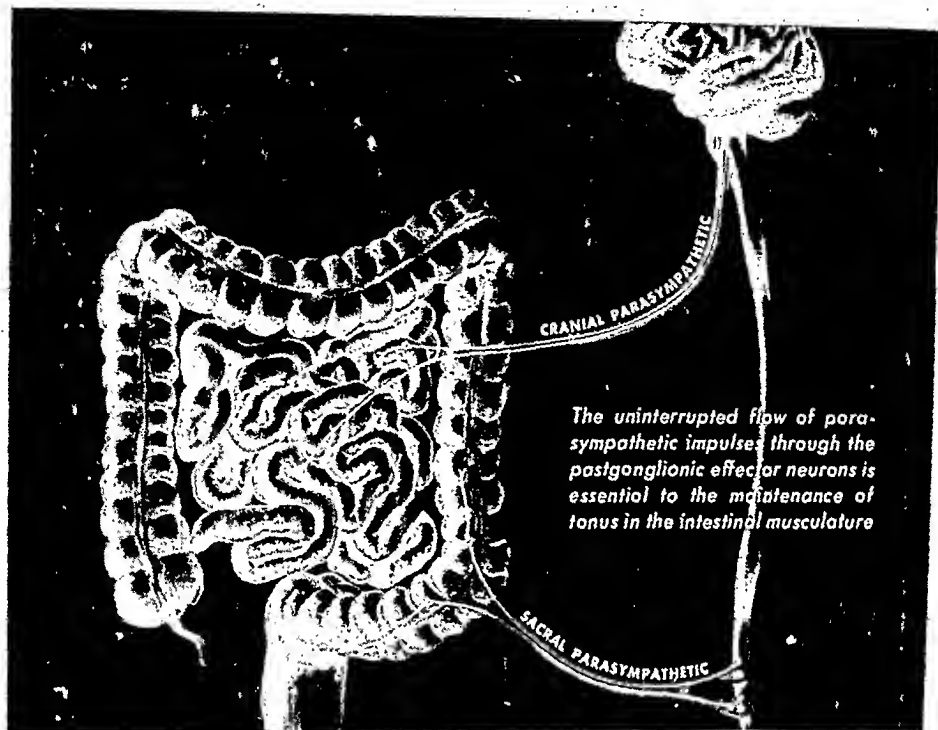
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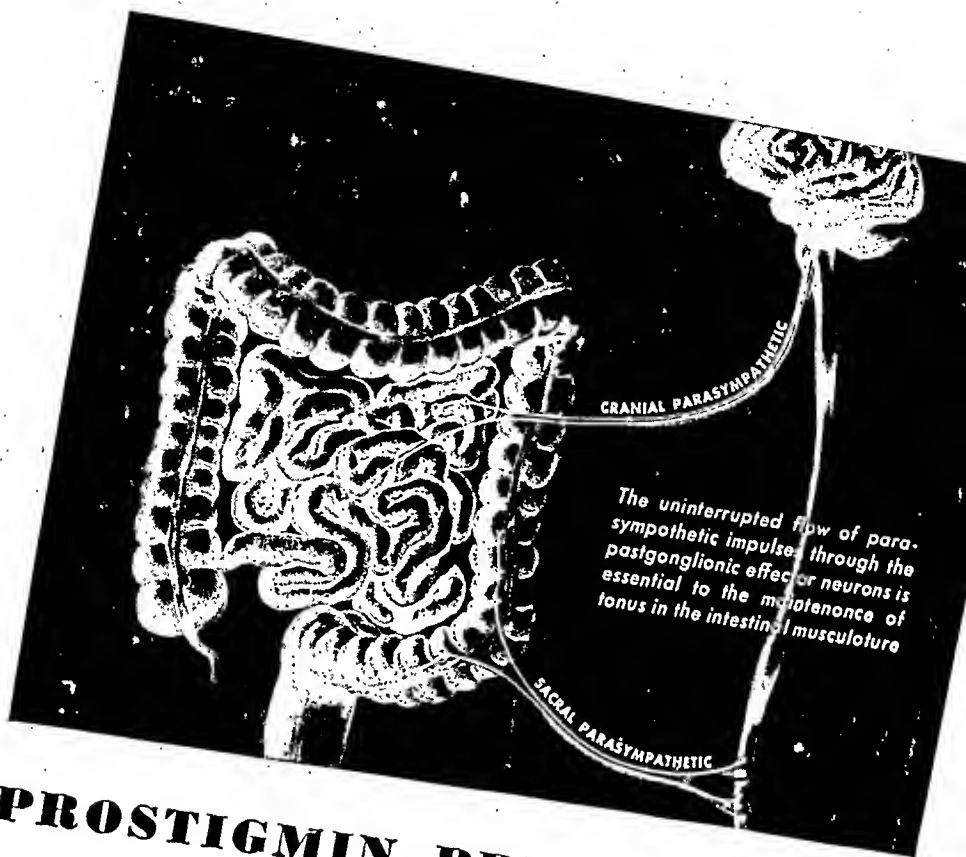
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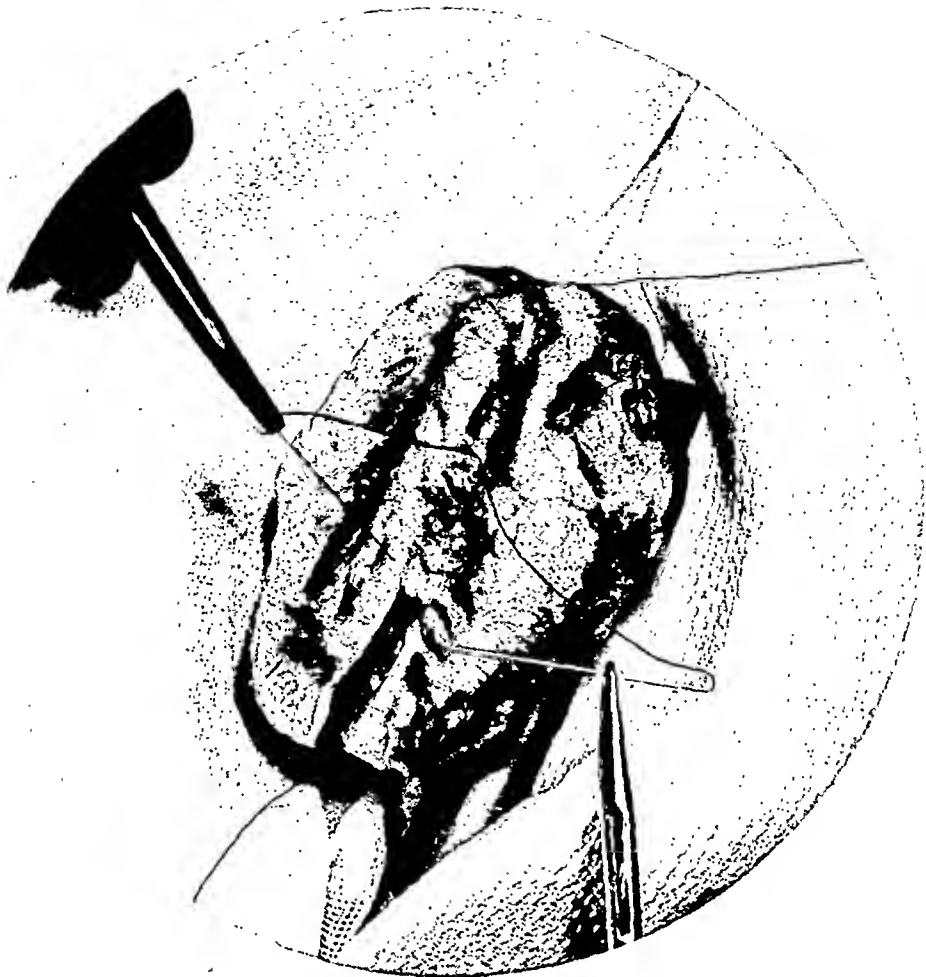
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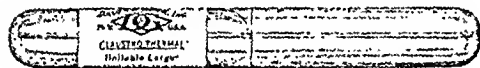
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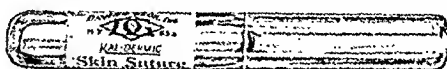
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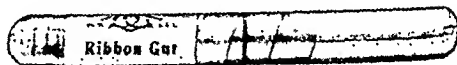
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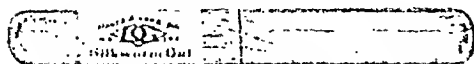


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3. *Cancer of the Stomach.* Horsley, J. Shelton, *Amer. Jour. of Surg.* April, 1939.
4. *The Cause of Death in Acute Diffuse Peritonitis.* Steinberg, Bernhard, *Arch. of Surg.* July, 1931.
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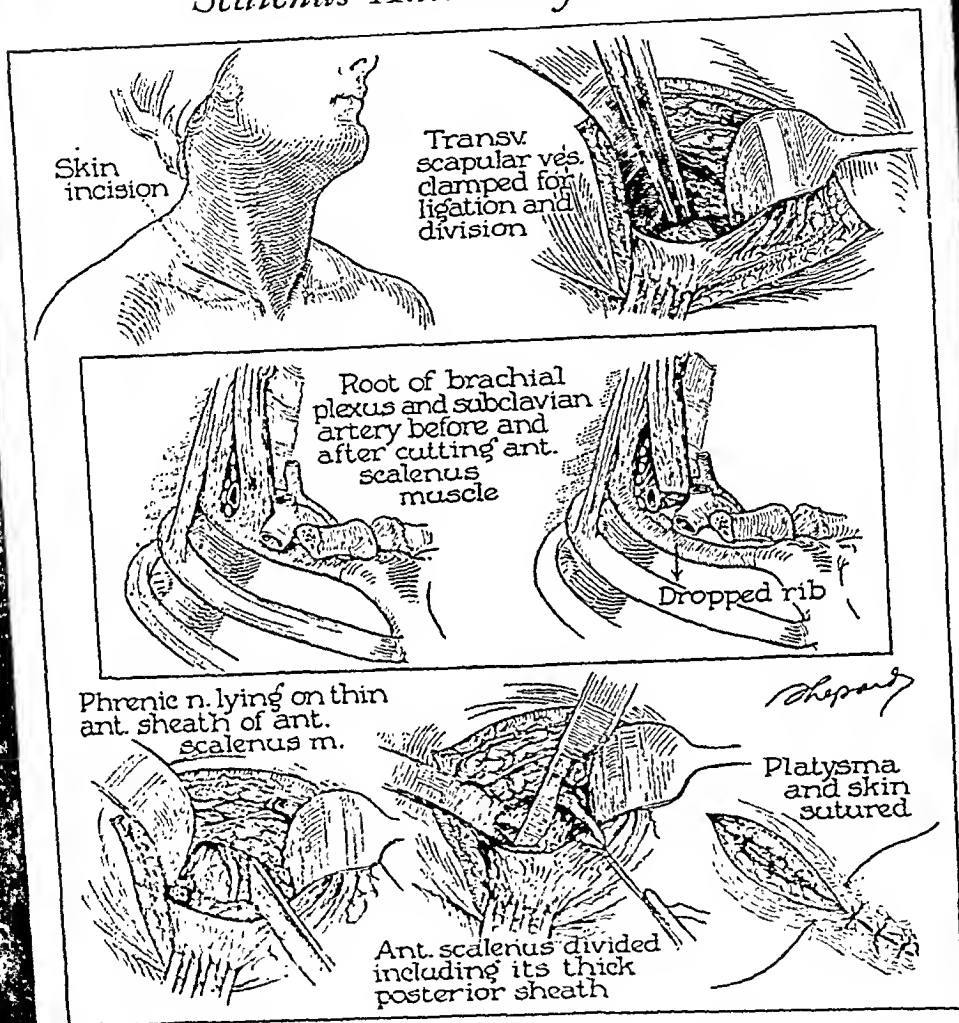
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OPERATIVE PROCEDURE

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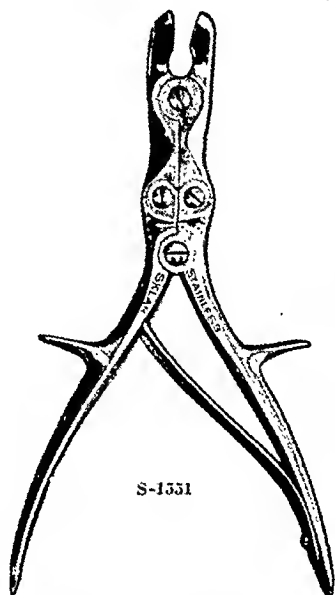
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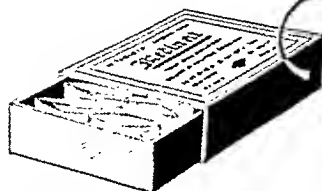
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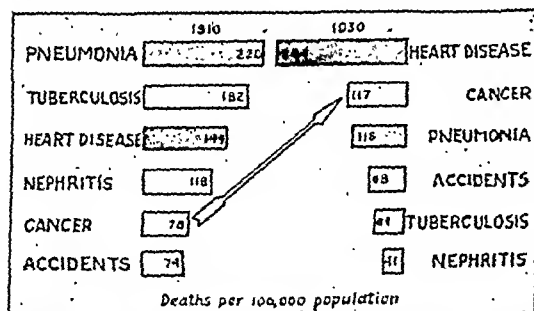
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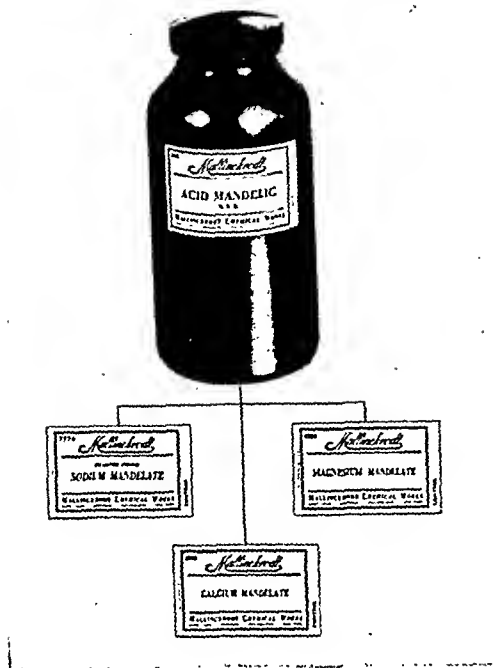
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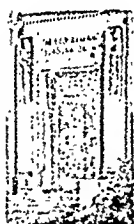
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Original Communications

THE TECHNIQUE OF NAILING OF FRACTURES OF THE NECK OF THE FEMUR

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I. INTRODUCTION

PATIENTS with fractures of the neck of the femur very often are in poor general condition. Not infrequently the treatment is made difficult by complications, such as great age, senile debility, hardening of the arteries, lesions of the cardiovascular system, emphysema, bronchitis, kidney lesions, and so forth.

In high degree this applies to patients admitted to the public hospitals, a category in which the Ullevål Third Surgical Service belongs. While the material in the private clinics as a rule is selected, the public hospitals have to take care of numerous patients in exceedingly poor condition with fractures of the neck of the femur. This material has always represented a *cruce medicorum*.

The poor general condition of the patients demands, before all, gentle treatment, medically as well as from a hospital-technical point of view. Major operative intervention and other exacting methods cannot be adopted as routine treatment for these patients.

We are aware from previous experience that even the so-called conservative treatment of Whitman-Löfberg¹ may represent a great strain upon the patient's resources. This method, furthermore, has not been used previously in a very great percentage of the material of the Third Surgical Service.

Also, from a hospital-technical point of view, this group of patients represents a problem. The slow and poor healing of the fracture has necessitated a lengthy stay in the hospital, in some cases for more than one-half to three-quarters of a year. The poor general condition and the fracture itself have made the nursing very difficult and troublesome to the patient as well as to the hospital staff.

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Reduction of the fracture should be carried out as quickly as possible after the accident, for many reasons. When admitted into the hospital, however, these patients often are greatly exhausted due to the trauma itself. The injury and the fracture cause a considerable reaction in many of these patients who are delicate beforehand (such reactions, for example, as circulatory deficiency, rise in temperature, pulmonary complications) with the result that the situation may be difficult to judge shortly after the accident.

It has been the practice, therefore, in several hospitals to leave the patient with the fracture unreduced for eight to ten days after the accident, thereby allowing this primary reaction to subside.

It is disadvantageous, however, to allow the patients to lie with the fracture unreduced. Deformity causes pain; the nursing becomes difficult. The ends of the fracture may exert pressure on the large vessels, cause circulatory deficiency and thrombosis of the vessels in the leg.

Reduction on a traction table also frequently constitutes a considerable strain on these patients. It calls for general or spinal anesthesia. The change of position alone, the rough manipulation, and the handling of the patient easily cause circulatory embarrassment. Some years ago two cases of sudden death occurred on the Third Surgical Service during reduction of fractures of the neck of the femur done on a traction table. One of these was verified as being due to pulmonary embolism.

These experiences teach us that the reduction of fractures of the neck of the femur should be performed as quickly as possible after the accident and as gently as possible, preferably without the aid of general anesthesia and without use of a traction table.

This is obtained by using Kirschner or Johansson wire traction for the reduction of the fracture carried out immediately, or as quickly as possible, after the accident. Schilling, the previous chief of the Third Surgical Service, for many years had used wire traction and Steinmann pin traction for the reduction of fractures of the neck of the femur, in part as preliminary treatment prior to a subsequent plaster treatment, in part as independent treatment, particularly of lateral fractures.

Wire traction may be applied under local anesthesia without causing any strain on the patient. Experience has proved that by this method an excellent reduction may be obtained in a simple manner.

In order to ensure an effective internal rotation of the lower fragment, I have constructed a rotative splint which makes the reduction by traction easier and more effective.

When the fracture has been reduced by wire traction, one may keep, without need for haste, the patient under observation, and one may postpone further treatment until the first reaction after the trauma has subsided. One has the opportunity then of judging the general condition of the patient correctly. Reduction and fixation of the fracture by wire traction also facilitates the nursing of the patient.

Fixation of the Fracture.—Fractures of the neck of the femur need fixation of very long duration in order to ensure firm union; lateral fractures from three to four months; medial fractures, one-half to one year.

Prolonged immobilization by plaster (as by the Whitman-Löfberg method) entails danger of pulmonary complications, circulatory deficiency, intestinal complications, bedsores, and so forth. Prolonged immobilization by traction is tolerated better by the patients, although recumbency for one-half to one whole year always means a great strain on the patient. Lengthy immobilization of patient and extremity is unfavorable, also, for the functional result, causing as it does muscular atrophy and contracture of joints.

At an early period, nailing of fractures of the neck of the femur was used to a considerable extent by Scandinavian surgeons. Nicolaysen (Oslo)² in 1879 demonstrated some cases which had been nailed percutaneously.

Schilling³ in 1915 to 1916 constructed a square nail which he used for percutaneous nailing after reduction and plaster.

Smith-Petersen⁴ (Norwegian born) introduced his open reduction at Ullevål in 1929. During the years 1931 to 1934 five, eleven, sixteen, and sixteen nailings respectively were performed on the Ullevål Third Surgical Service. Experience then taught us that the nail had to be made of rustless steel, as otherwise it might cause aseptic necrosis due to electrolysis.

Smith-Petersen's construction of the three-flanged nail for internal fixation has made it possible to effect a reliable fixation of the fracture without immobilizing the entire patient correspondingly.

The available end results also definitely indicate that this method offers considerably better chances of bony union than any other method.

Efforts in recent years have been concentrated on simplifying Smith-Petersen's original open operation.

As early as 1931 Schilling used a guide wire to aid in the insertion of the nail, along the wire, as well as a nail model with a cannulated head for accommodating the guide wire. At about the same time, Schilling, and independently of him another Norwegian, Baeker-Grøndahl,⁵ fixed the fracture with the aid of three wires which were inserted percutaneously and by this method, the so-called "wire nailing," obtained some good results.

Smith-Petersen himself has abandoned the traction table and now performs manual reduction of the fracture on the operating table immediately prior to the operation. The nail is inserted through a small incision under roentgenographic control.

Johansson's⁶ and Jerusalem's constructions of the cannulated nail (1932) has meant a simplification of, and a certitude of correct direction of, the nail, and gives an exact and easy determination of the proper length of the nail.

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TABLE I

157 CASES OF FRACTURES OF NECK OF FEMUR (1935-1937)

| | | TOTAL | NO TREAT- MENT | WIRE TRACTION ONLY | TRACTION + WIRE NAILING | TRACTION + NAILING |
|---|-------|-------|----------------------|--------------------------|-------------------------------|--------------------------|
| Lateral and per- trochanteric frac- tures | 1935 | 5 | 0 | 0 | 2 | 3 |
| | 1936 | 13 | 0 | 2 | 3 | 8 |
| | 1937 | 20 | 2 | 11 | 1 | 6 |
| | Total | 38 | 2 | 13 | 6 | 17 (45%) |
| | | | | | 23 (60%) | |
| Medial fractures | 1935 | 24 | 0 | 0 | 4 | 20 |
| | 1936 | 51 | 0 | 4 | 1 | 46 |
| | 1937 | 44 | 2 | 7 | 1 | 34 |
| | Total | 119 | 2 | 11 | 6 | 100 (84%) |
| | | | | | 106 (89%) | |
| Medial, lateral, and perthrochan- teric fractures | Total | 157 | 4 | 24 | 12 | 117 |
| | | | | | 129 | |

Indications for Application of Wire Traction on Special Splint.—As far as possible all fractures of the femoral neck are treated with wire traction immediately after admission to the hospital. This applies to the medial as well as to the lateral and trochanteric fractures. This has been performed in a total of 153 of 157 cases (97 per cent).

Three patients only were regarded as being too ill for this treatment, and all three of them died shortly afterward. In one case, an impacted medial fracture in valgus position, the treatment was regarded as superfluous.

The primary object in the application of wire traction on the adjustable rotation splint is reduction and fixation of the fracture, but in some instances only immobilization is desired; i.e., impacted fractures in good position. In the majority of medial, and in some of the lateral, fractures this constitutes the treatment preliminary to the subsequent operative fixation.

The treatment with wire traction makes possible observation and evaluation of the general condition of the patient, and thereby gives the correct indications for operative treatment.

During this observation, some cases of medial fractures are found to be too ill for operation (a total of 11 of 119 medial fractures in this material). The wire traction furnishes an excellent palliative treatment for these very ill patients (10 of 11 died in the hospital and 1 was insane), as it relieves the pain and, the chief advantage, facilitates the nursing.

In some lateral and in the majority of the trochanteric fractures, traction on the described splint represents the chief treatment of the fracture.

Indication for Operative Treatment is not the same for the medial as for the lateral fractures. The medial fractures should be nailed to as

In order to make the nailing as gentle as possible, we have in recent years at the Ullevål Third Surgical Service performed the nailing with the patient in bed, so as to avoid the use of the traction table.

THE AUTHOR'S METHOD

Immediately after admission to the hospital, wire traction is applied with the leg on a specially constructed rotative splint. As a rule an ideal reduction is obtained in the course of a few days by this method. The patient is observed and the indications for, as well as the most favorable time for, operation may be determined. When the general condition of the patient allows it, he is moved in his bed to the operating room and the nailing is performed with the patient lying in bed, traction being maintained.

The nailing's being performed with the leg on a splint, flexed in the hip joint, has made it necessary to construct a special alignment or sighting apparatus to facilitate the centering of the nail in two planes.

The advantages of this procedure are the following: It gives a speedy and good reduction of the fracture. The time for carrying out the operation may be chosen regardless of the reduction, when the condition of the patient permits. The operation need not be hurried into. One reduction only is necessary. The leg remains in the same position and on the same splint from the time of the reduction, immediately after admission, until after the nailing. One avoids the traction table, rough manipulation of the patient, and lengthy general or spinal anesthesia. The operation is relatively easy to perform.

The classification of fractures of the femoral neck has been simplified in accordance with the outline of *Anschütz*:

1. The *medial*—fractures in the narrow, medial end of the femoral neck.
2. The *lateral*—fractures in the transition between the femoral neck and the trochanteric region. In addition to these are:
3. The *perthrochanteric* or *intertrochanteric* fractures respectively in the actual trochanteric region.

The medial fractures are distinctly separated from the other two groups, and should not be confused with these.

Because of the poor condition of nutrition of the central fragment and the great tendency to pseudarthrosis, the treatment of medial fractures presents great difficulties. The prognosis is considerably better for the lateral and pertrochanteric fractures. These latter two groups have been considered together.

II. INDICATIONS

A survey of the treatment of all fractures of the neck of the femur admitted to the Third Surgical Service during a given period, a total of 157 cases, illustrates the indications for the methods of treatment used (Table I).

than 60 years of age; 51 patients, more than 70 years of age; and 14 patients, more than 80 years of age.

TABLE II
AGE OF PATIENTS WITH NAILED MEDIAL FRACTURES

| AGE | NUMBER |
|---------------------|------------|
| Under 40 years | 3 |
| From 40 to 49 years | 5 |
| From 50 to 59 years | 14 |
| From 60 to 69 years | 27 |
| From 70 to 79 years | 37 |
| From 80 to 89 years | 14 |
| | <u>100</u> |

The preoperative complications can be seen from the table: debility, hardening of the arteries, heart disease, apoplexy, cerebral syphilis, insanity, diabetes, asthma, and so forth. None of these lesions are regarded as definite contraindications.

In spite of preliminary treatment, some of the patients are too ill to stand any operative intervention whatever. In this material this was the case with a total of 11 patients, and these were treated with traction only. *Ten of these 11 patients died in the hospital.* This shows that the indication for nailing has been very radical. It indicates also that the method of observation used has been effective, having spared these 10 desolate patients a superfluous nailing.

The circumstances seem to demonstrate that some patients (in this material approximately 10 per cent) are so ill and exhausted after the fracture that they die regardless of the treatment to which they are subjected.

In some of the cases of ill patients who are observed during treatment with traction, the decision may be very difficult and may depend greatly on a personal estimate and personal experience.

A total of 119 medial fractures have been admitted, of which 117 have been treated with traction on admission (98 per cent). Of these 117 patients, 100 have been nailed and 6 "wire nailed," while 11 were too ill for nailing.

The material proves that this procedure supplied us with a treatment which makes possible the use of nailing as method of choice in 84 to 89 per cent of all cases of medial fractures admitted; that is to say, practically all the cases which are suitable for any active treatment at all.

In 6 cases of medial fractures so-called "wire nailing" has been performed. This method is relatively little used now, because it does not offer essential advantages in preference to ordinary nailing of medial fractures. It is not so certain in its effect; the wire easily slips out, and it calls for a more lengthy recumbency. It may be used in some

great an extent as possible. As far as firm union is concerned, nailing appears to yield better results than all other methods. It reduces the time of treatment and makes possible the mobilization of the patient, both within a reasonable length of time. Nailing may be indicated also for the patients who were ill, more or less bedridden, before the fracture occurred as it serves to facilitate and improve the nursing of these patients.

For these various reasons, nailing is the method of choice, practically speaking, in all cases of medial fractures of the neck of the femur. As a rule, impacted fractures also should be nailed. Furthermore, we have not made any exception for fractures with a fairly horizontal fracture surface (Pauwels⁷).

Nailing is unnecessary only in those cases where the fracture is so firmly impacted or so incomplete that plaster bandage or other immobilizing bandage is superfluous. In my material only one such case is found in 119.

The chief object of the development of my method has been to make it so gentle that it may be used in as many of these cases as possible. With this method, preliminary treatment of the patient with wire traction and nailing in bed under local anesthesia, the immediate postoperative reaction has been slight; in no single case has it been threatening. This justifies extensive use of the nailing procedure.

As mentioned before, however, these patients are frequently in poor general condition and are able to stand very little strain. The indication for nailing, therefore, should not be determined until after observation and preliminary treatment for some time. Nailing immediately after the accident is contraindicated as it entails greater risk and because it is quite superfluous.

One should wait, as a rule, for at least one week in order that the patient may recover from the trauma. If one is in doubt, nothing is forfeited by waiting for a longer period.

The fracture remains unchanged in traction until after the nailing, and during this time the patient is accessible to preliminary treatment.

By varying the length of this period of observation and preliminary treatment according to the individual patient, one is able to get as many of the patients as possible in such shape that they can well tolerate the intervention. In this way the indication for nailing is increased to an optimum.

The duration of this period of observation and preliminary treatment varies greatly, from eight days to several months.

The age of the patients with nailed medial fractures appears in Table II. In this material, nailing has been performed in 100 patients with medial fractures of the femoral neck, of which 78 patients were more

Roentgenographic control of the position is carried out easily by exposure in two planes (see Figs. 4, 5, and 6). If the x-ray control film shows that the position is not ideal, it may be gradually corrected. The traction may be increased or reduced by changing the weight; the rotation may be increased or reduced by rotating the leg part of the splint. By means of this slow reduction, traction and internal rotation are obtained simultaneously and gradually, which appears to be the ideal procedure. This method of reduction does not necessitate general or spinal anesthesia.

The method has furnished excellent reduction in 98 per cent of all the cases of medial fractures in this material. In the first cases, however, this rotative splint was not used (Table III). In only two cases has it been necessary to perform manual reduction in spinal anesthesia. In these two cases the fracture surface has been irregular and with a

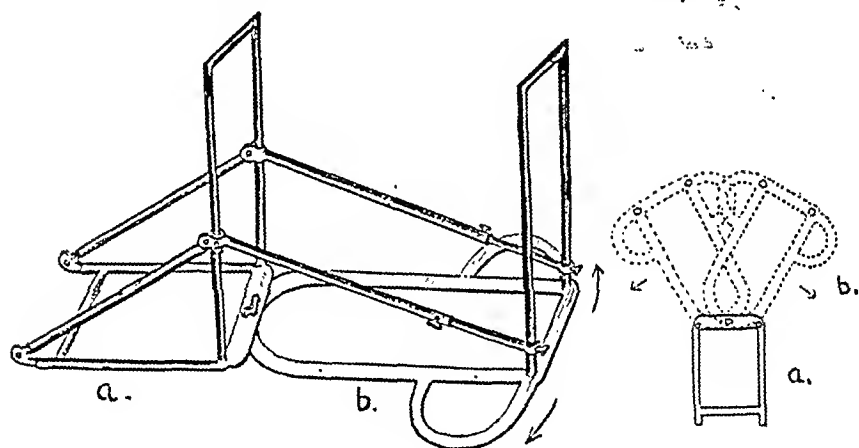


Fig. 1.—Rotatable splint (Semb) for wire traction and rotation of the femur; a, the "femur part," adjustable to different lengths and different degrees of flexion in hip and knee joint; b, the "leg part," adjustable to different angles in the knee joint and rotative, the femur is rotated inwards by swinging the "leg part" outwards.

distinctly oblique course (refer to "Panwels III"). A protruding part of the lower fragment has hitched on to the fracture surface of the upper fragment and has rotated this backward during the internal rotation.

Complete relaxation in spinal anesthesia and manual reduction have given satisfactory results in these cases. When reducing these fractures, lateral traction is first applied according to Contremoulin and Robineau,² and then reduction according to Smith-Petersen's method with the hip flexed at 90 degrees and with simultaneous internal rotation.

The lateral fractures have presented no particular difficulties with regard to reduction.

In pertrochanteric fractures, splintering may make a complete reduction difficult. In spite of this, however, these fractures may heal.

very ill patients in cases of impacted fractures in good position. This method may have a somewhat wider use in lateral and trochanteric fractures.

The lateral fractures or trochanteric fractures, respectively, in themselves have a relatively greater tendency to bony union within a reasonable time, and indication for operation, therefore, is more restricted than for the medial fractures.

The advantage of the nailing of these fractures is a shortening of the course and a better functional result, less atrophy and less contracture than occur in the use of its competitor, the traction treatment or plaster treatment.

Some of the patients with lateral fractures, i.e., those in fairly good general condition, have been nailed, and in addition some patients in whom the traction treatment has not given union in good position. The pertrochanteric or intertrochanteric fractures, respectively, are not generally suitable for nailing due to splintering of the trochanteric region so that the nail does not get a good grip.

A total of 17 of 38 of these fractures have been nailed, about 45 per cent.

III. TECHNIQUE

The Reduction.—A very accurate reduction of the fracture, controlled in two planes, is a necessary condition for the nailing.

The wire traction is usually applied through the tibial tuberosity (the lower end of the femur may also be used) under local anesthesia. Extension is obtained with twelve to twenty-four pounds (or more) of traction, varying in accordance with the size of the thigh muscles. In this way shortening is combated fairly easily; traction also increases abduction of the femur in relation to the pelvis.

It is not necessary to attain marked abduction; 10 to 15 degrees is sufficient. Too strong abduction may be unfavorable to reduction.

Flexion in hip and knee joints furnishes the most effective relaxation of the muscles. Furthermore, a flexed hip joint gives relaxation of the anterior part of the capsule with the strong iliofemoral ligament. The disadvantage inherent in the application of an ordinary straight Braun's splint is insufficient internal rotation of the lower fragment. I have succeeded in obtaining an effective internal rotation by the construction of an adjustable, rotative splint which permits maximum internal rotation of the femur (see Figs. 1, 2, and 3). The distal half of this splint, "the leg part," may be rotated in relation to the proximal half, "the femur part." The distal part of the splint with the lower leg is used as a "handle" with which the femur is rotated inward by swinging the foot and lower leg outward. The splint permits adjustment of the leg part and femur part to different lengths and with varying degrees of flexion in hip and knee joints.

The method of reduction used, with wire traction on the internal rotation splint, has furnished remarkably good results, satisfying even the most exacting requirements. This is particularly the case with the medial fraetures.

It is probable that it is simply this slow traction, during which the extension and the internal rotation act fairly simultaneously and in a gentle manner, which is the most favorable treatment of these fraetures. The limited degree of abduction may also be of importance in obtaining good results.

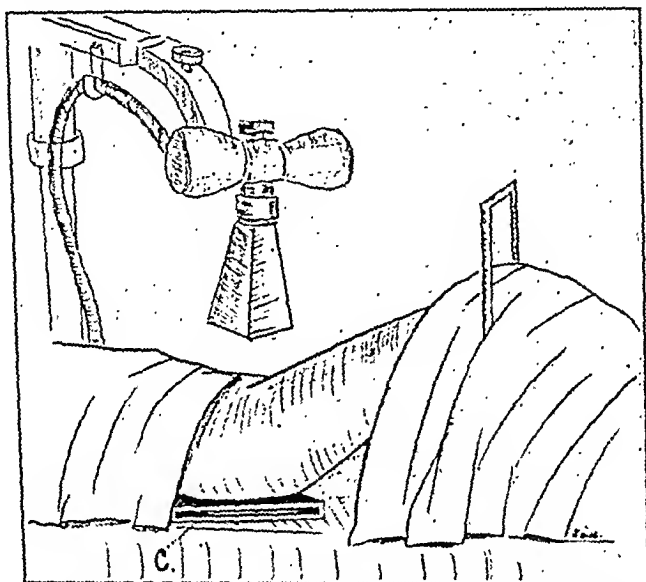


Fig. 1.—X-ray in the anteroposterior plane. A wooden cassette-holder (c) is placed under the splint and patient for changing films without lifting the patient.

THE OPERATION

As mentioned, the actual nailing is performed with the patient lying in bed and the leg in unchanged position on the splint with constant traction maintained (Fig. 7). A modified Smith-Petersen-Johansson technique is used.

In order to be able to take roentgenograms easily during the operation, a wooden cassette-holder is placed under the splint and patient, enabling change of x-ray films for exposures in the anteroposterior plane without moving or lifting the patient (Fig. 4). For lateral exposures, the x-ray machine is placed in the groin; the unaffected leg is lifted (Figs. 5 and 6). A curved cassette is not necessary. It is an advantage to be able to use two x-ray units at the same time.

Anesthesia.—Infiltration anesthesia corresponding to the incision below the greater trochanter as well as anesthesia of the fracture line and the hip joint are employed.

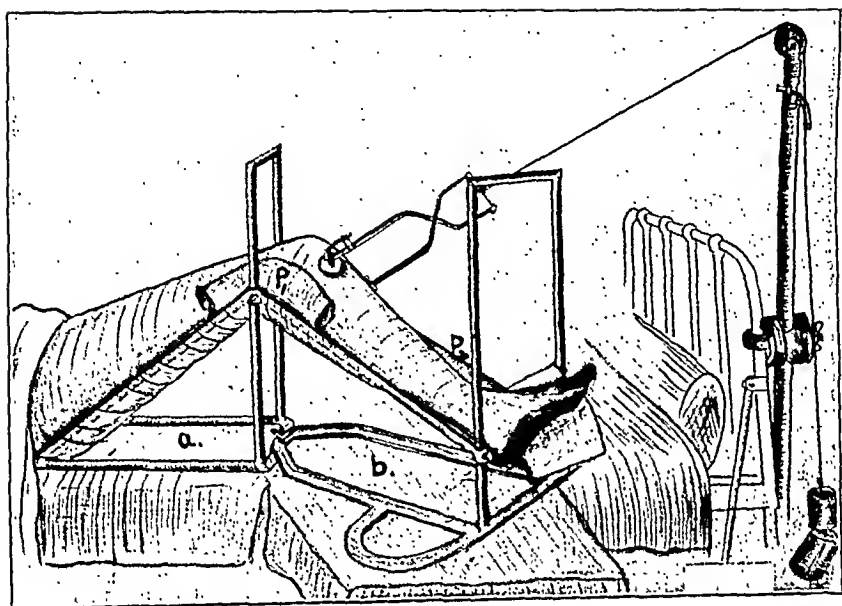


Fig. 2.

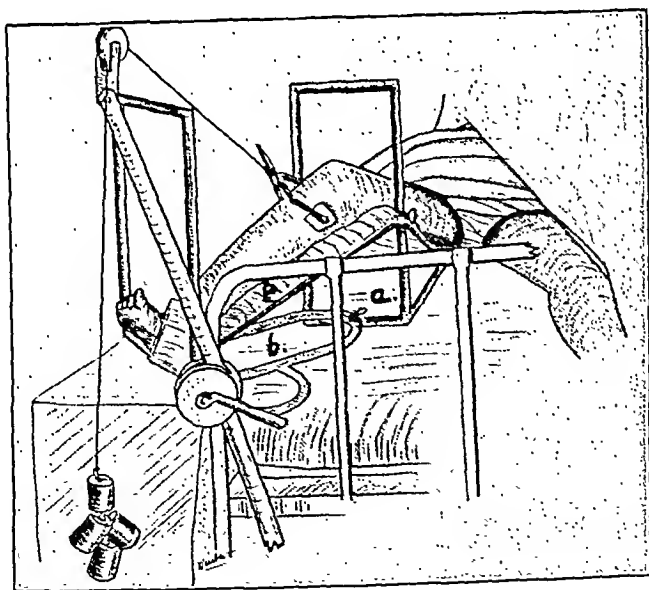


Fig. 3.

Figs. 2 and 3.—Wire traction on a rotative Senn splint. Application of the traction through the tibial tuberosity, slight abduction, flexion in hip and knee joint. The "leg part," *b*, is rotated outwards whereby the femur is rotated inwards P_1 , P_2 are pads.

During the introduction of the nail, the patient is given a little gas, ether, or evipan soluble for a few minutes.

Alignment of the Wire.—An accurate centering of the nail in two planes is a necessary condition for a good result in nailing. Before the actual operation commences, metal markers are placed for alignment

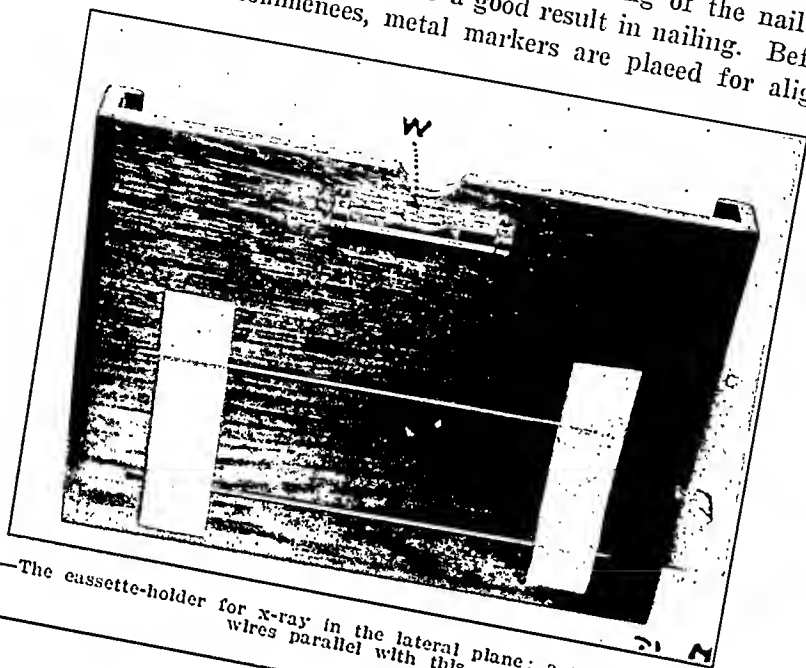


Fig. 7.—The cassette-holder for x-ray in the lateral plane; a water level and two wires parallel with this.

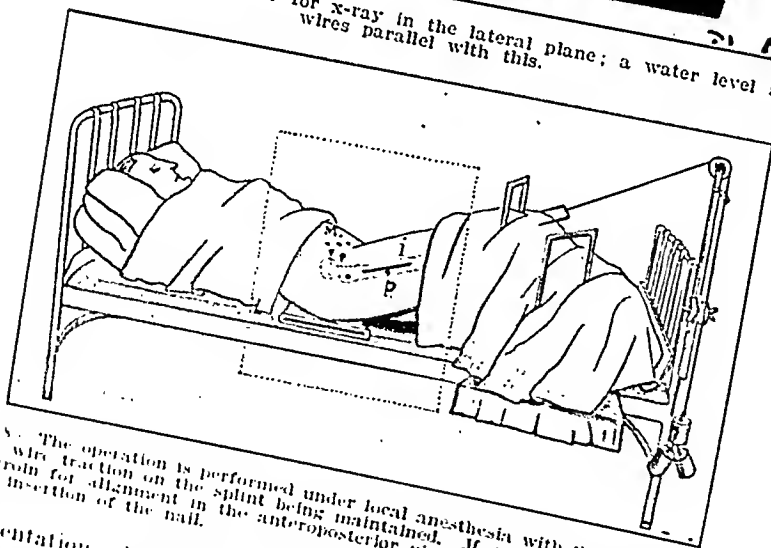


Fig. 8.—The operation is performed under local anesthesia with the patient lying in bed, the wire traction on the splint being maintained. *M*, metal markers on the skin in the groin for alignment in the anteroposterior plane; *P*, pin as a marker for the point of insertion of the nail.

and orientation. Three or four metal clips are fixed to the skin fold in the groin as alignment marks in the anteroposterior plane. Sighting at these marks is very easy with any kind of sighting apparatus. In the case of my model, this is accomplished by a curved arm which points directly at the place or mark at which one wishes to aim.

As anesthetic agent, a mixture of $\frac{1}{2}$ per cent of novocain (1:200) and one-half per mille of pantocain (1:2,000) in equal parts is used. This mixture furnishes anesthesia with a duration of approximately three hours.

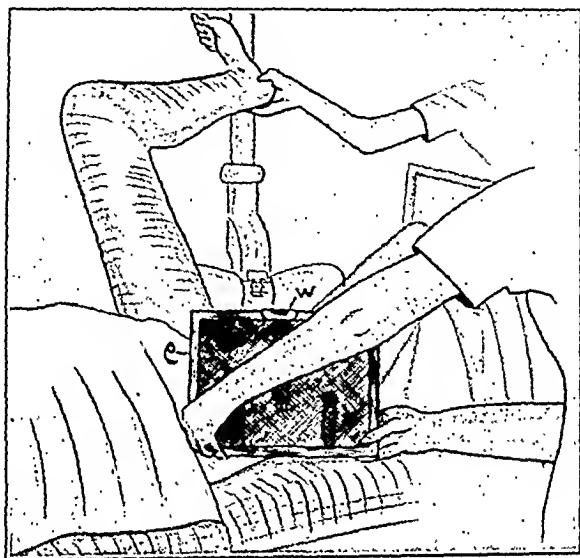


Fig. 5.

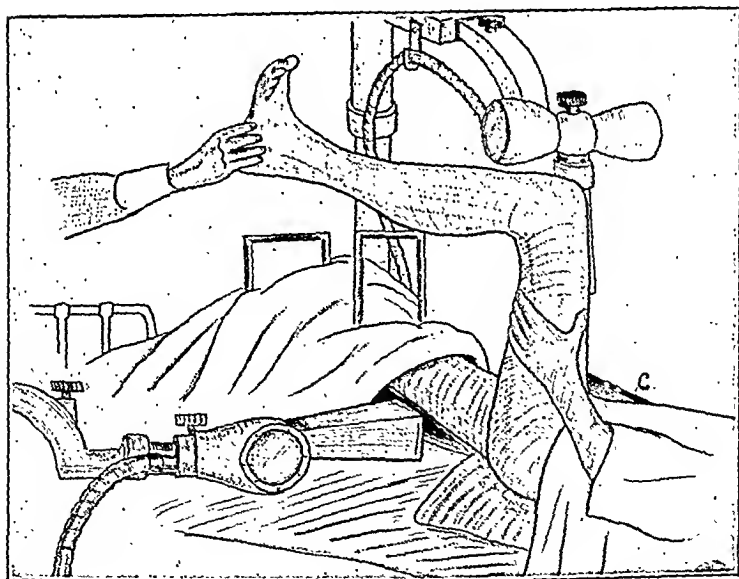


Fig. 6.

Figs. 5 and 6.—X-ray in the lateral plane. X-ray machine in the groin. A wooden cassette-holder (c) outside the trochanter region parallel to the femoral neck. The cassette is furnished with a water level (w) (see Fig. 7). Fig. 6 demonstrates the use of two x-ray units.

During the introduction of the nail, the patient is given a little gas, ether, or evipan soluble for a few minutes.

Alignment of the Wire.—An accurate centering of the nail in two planes is a necessary condition for a good result in nailing. Before the actual operation commences, metal markers are placed for alignment

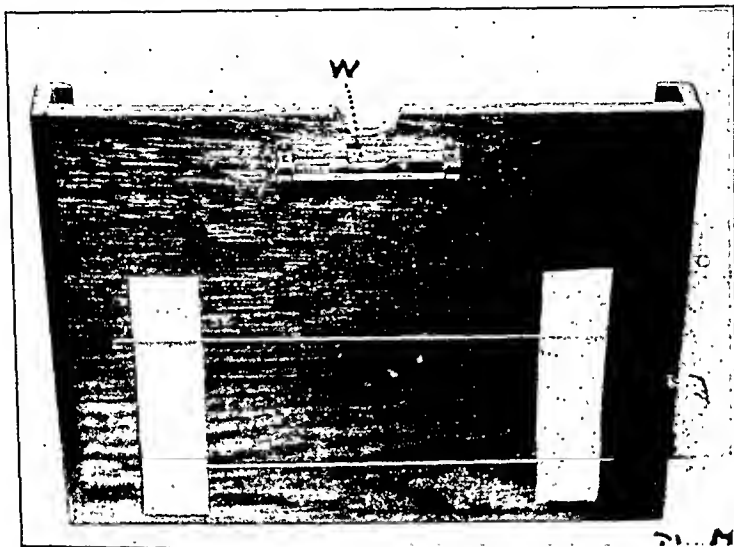


Fig. 7.—The cassette-holder for x-ray in the lateral plane; a water level and two wires parallel with this.

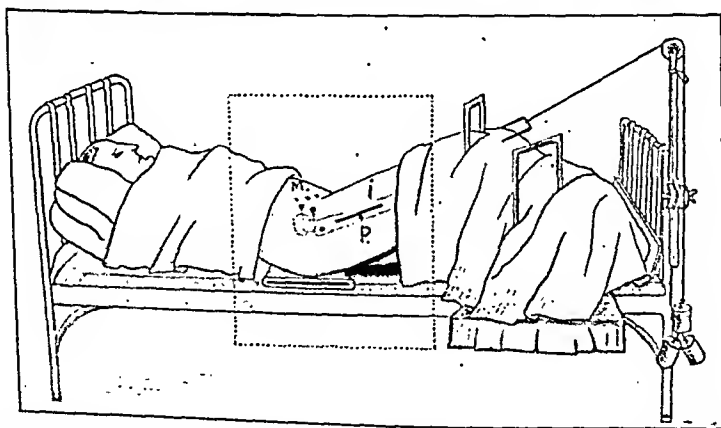


Fig. 8.—The operation is performed under local anesthesia with the patient lying in bed, the wire traction on the splint being maintained. *M*, metal markers on the skin in the groin for alignment in the anteroposterior plane; *P*, pin as a marker for the point of insertion of the nail.

and orientation. Three or four metal clips are fixed to the skin fold in the groin as alignment marks in the anteroposterior plane. Sighting at these marks is very easy with any kind of sighting apparatus. In the case of my model, this is accomplished by a curved arm which points directly at the place or mark at which one wishes to aim.

In order to get a landmark for the insertion point of the wire into the femur, a pin is driven into the femur just distal to the greater trochanter laterally. The actual point of insertion is located in accordance with the center of the thickness of the femur about 2 cm. below the trochanter.

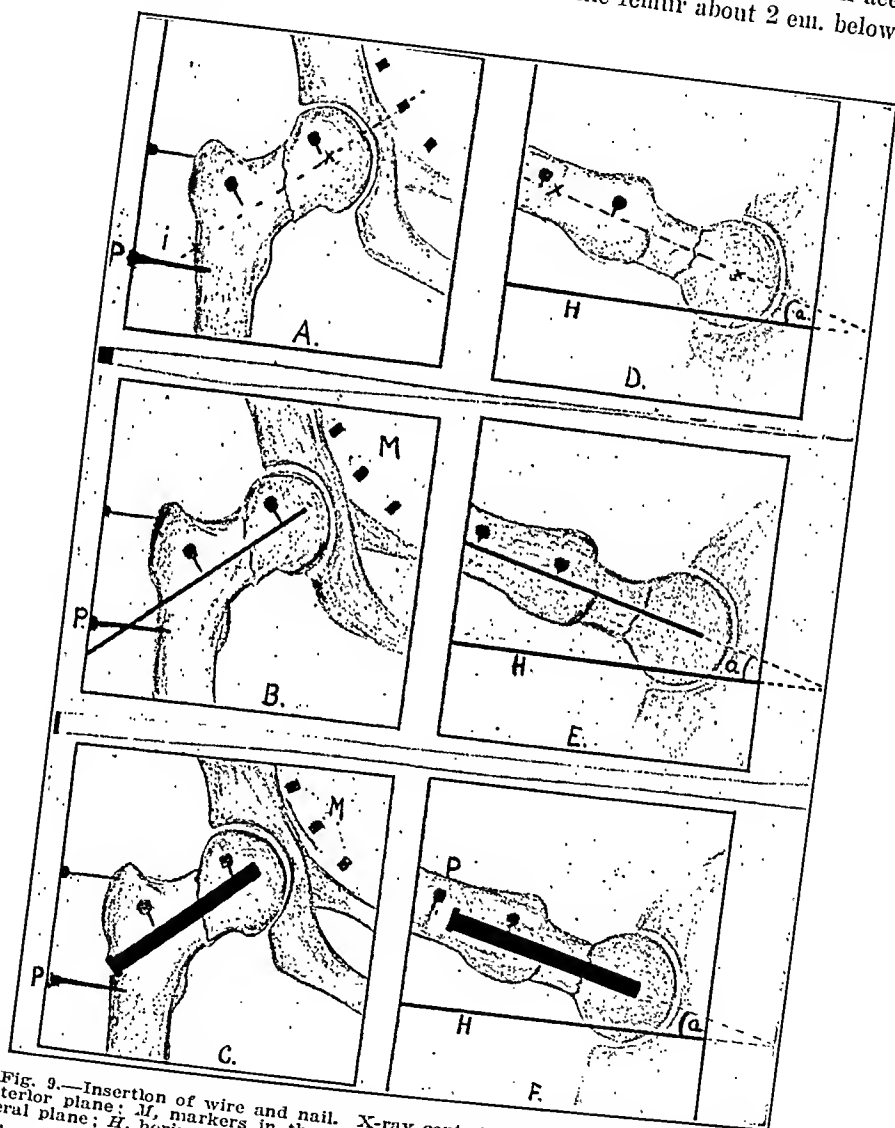


Fig. 9.—Insertion of wire and nail. X-ray control in two planes; A, B, C, anteroposterior plane; M, markers in the groin; P, pin for the insertion point; D, E, F, lateral plane; H, horizontal line; a, angle between the femoral neck and the horizontal line.

The sighting in the lateral plane is more difficult. Because of the flexed position on the splint, the femoral neck forms an angle of 15 to 30 degrees with the horizontal plane. It is difficult to estimate this

angle when introducing the wire. I have endeavored, therefore, to measure this angle exactly on the roentgenogram in each separate case and to register this angle on a sighting apparatus.

The horizontal forms for this purpose the firm, unchangeable basis.

It is possible to reproduce the horizontal line on the roentgenogram by supplying the cassette-holder with a water level and one or two wires parallel with this (Fig. 7). The central axis of the neck of the femur is marked on the x-ray film, from the point of insertion decided on for the wire to the center of the femoral head.

As no previously known sighting apparatus can be adjusted to definite angles to the horizontal plane, I have constructed my own sighting apparatus for this purpose (Fig. 10). On the sighting apparatus also the horizontal line is marked by a water level.

The sighting apparatus is supplied with a scale for adjustment to a given angle to the horizontal plane; i.e., the water level. When during the drilling the level is held horizontally, the wire consequently must be inserted into the femur at the desired angle to the horizontal plane.

With the aid of this sighting apparatus of the author's, therefore, one is able to adjust the wire in two planes in accordance with the anteroposterior and lateral roentgenograms.

By accurate marking and by photographing in correct planes, vertically and horizontally, and by accurate aim, the wire in most cases enters correctly at the first attempt. An incorrect direction may be rectified by another wire.

The constructed sighting apparatus is affixed to an electric drill in order to avoid the inaccuracy of manual drilling.

A drill is used which is supplied with a point constructed by Haugland and which "shoots" the wire out of the handle. This prevents displacement of the sighting apparatus during the drilling. The actual sighting apparatus, of course, may be affixed to any kind of drill.

The sighting apparatus has been constructed so as to be as simple as possible. For this reason it has been prepared for free adjustment without being fixed to the bed.*

From our material one can see that, in the first cases, i.e., where we did not as yet have the sighting apparatus, we frequently had difficulty, especially in the lateral plane, in centering the wire or the nail accurately. Since we began to use the sighting apparatus and skin clips and pins as markers, as described, this difficulty has been overcome. As a rule the guide wire enters the center of the femoral head on the first attempt.

*This apparatus is manufactured by Norsk Medicinsk Værkhus, Oslo, Norway, where the relative rotation splint also may be obtained.

The incision is made immediately before the insertion of the wire. It should be made about 1 to 2 cm. anteriorly to the middle of the trochanter and femur because of the tendency of the soft parts to sag (Figs. 8 and 11). The wound edges should be carefully covered by compresses which are fixed with sutures. Metal clips interfere with the roentgenograms.

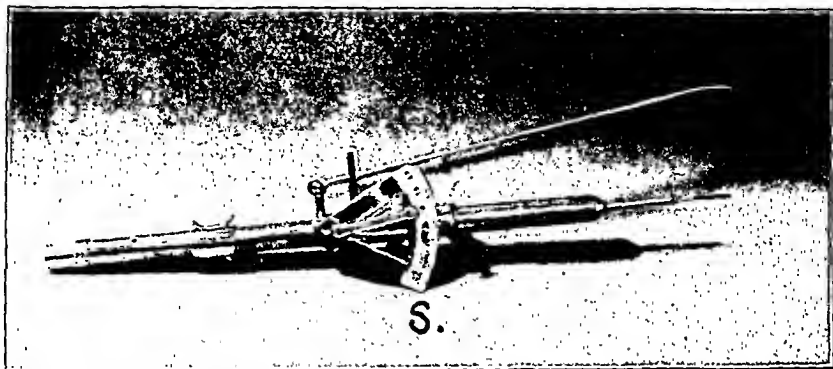


Fig. 10.—The sighting apparatus (Semb). A curved arm (*a*) for sighting at the markers in the groin. A scale (*s*) with water level for adjustment to a given angle to the horizontal plane.

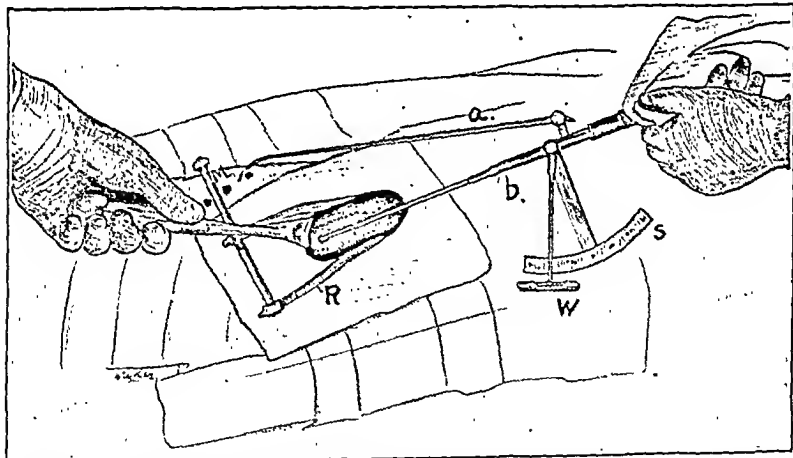


Fig. 11.—The use of the sighting apparatus (a somewhat older model). *a*, the curved arm pointing at the marker in the groin; *b*, the drill with the wire at a given angle with the horizontal plane; *w*, a water level giving the horizontal line; *s*, scale for adjustment to the given angle; *R*, self-retaining retractor in the incision; *P*, markers in the groin.

The point of insertion for the wire is found with the guidance of the pin (Fig. 9, *P*) which was driven in as a marker. If the femur is thick and firm, a groove should be chiseled out for the nail. If the bone is brittle, this is not necessary.

The length of the nail to be used is determined in relation to the wire. All wires present on the operating table are of exactly the same

length. The length of the drilled-in part of the wire is easily determined by subtracting the length of that part which remains outside the bone from the standard length. It is important to calculate the length of the nail accurately.

One should make allowances for 3 to 5 mm. shortening of the neck of the femur during impaction and driving-in of the nail. The nail should not enter further than to about $\frac{1}{2}$ cm. from the surface of the head of the femur.

Prior to the final driving-in of the nail, the length and position are controlled by x-ray. A somewhat shorter nail may be inserted a little further than usual; a nail which is a little too long, less than usual.

In my opinion the nail should be fixed against the femur to prevent subsequent extrusion. This may be done by driving it so far in that

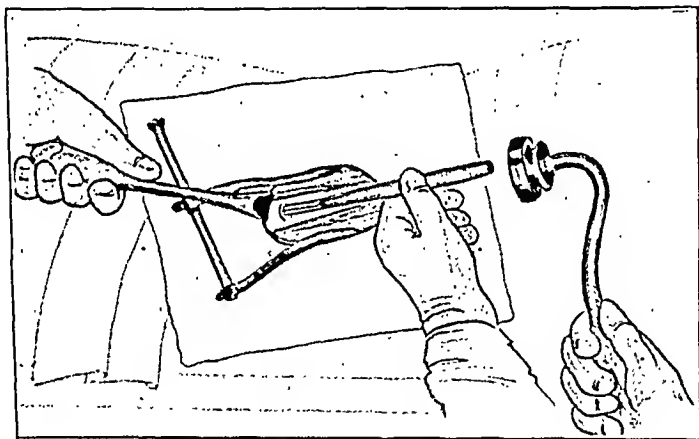


Fig. 12.—Insertion of the cannulated nail.

the lower edge of the head of the nail is supported against the external lamina of the femur (Fig. 9, C). The nail will hitch on and will not slip out. After some time has elapsed, it becomes entirely or partly covered by callus from the femur (Fig. 13, Case 24). This also prevents the nail head from irritating the soft parts and forming a painful bursa, which is demonstrable in cases where the head of the nail penetrates into the soft parts.

It has been held that, following a subsequent absorption of the femoral neck, the nail may become too long. The risk of this is so small that it cannot by any means outweigh the safeguard obtained by this technique against outward slipping.

After impaction of the fracture, the incision is sutured without drainage. The traction is removed immediately. The leg is placed on an ordinary Braun's splint.

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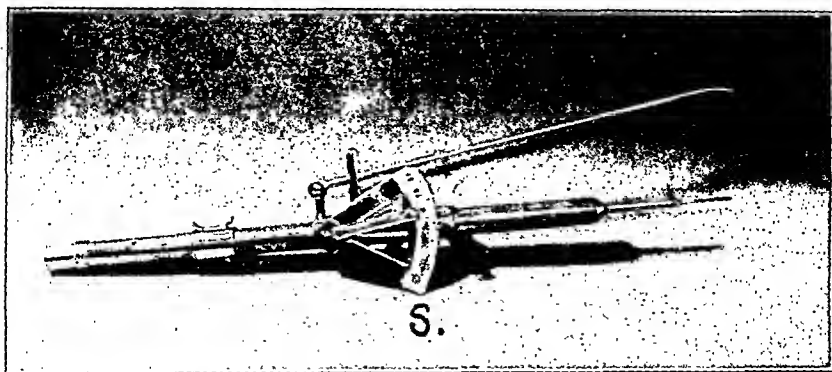


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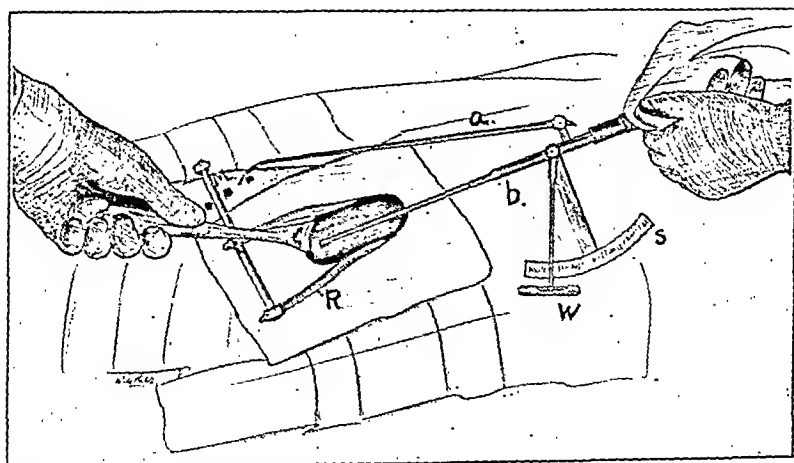


Fig. 11.—The use of the sighting apparatus (a somewhat older model). *a*, the curved arm pointing at the marker in the groin; *b*, the drill with the wire at a given angle with the horizontal plane; *w*, a water level giving the horizontal line; *S*, scale for adjustment to the given angle; *R*, self-retaining retractor in the incision; *M*, markers in the groin.

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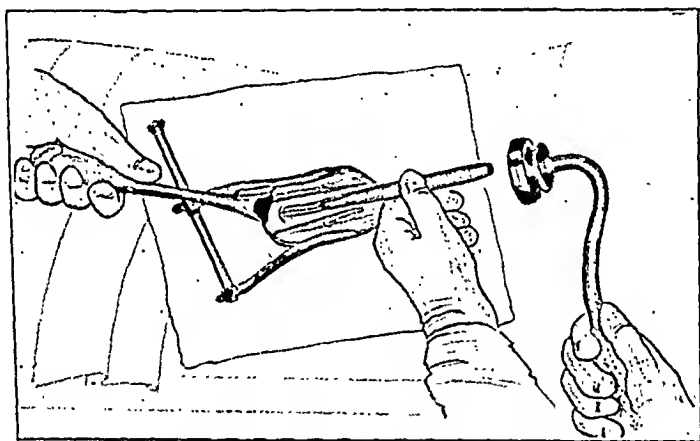


Fig. 12.—Insertion of the cannulated nail.

the lower edge of the head of the nail is supported against the external lamina of the femur (Fig. 9, C). The nail will hitch on and will not slip out. After some time has elapsed, it becomes entirely or partly covered by callus from the femur (Fig. 13, Case 24). This also prevents the nail head from irritating the soft parts and forming a painful bursa, which is demonstrable in cases where the head of the nail penetrates into the soft parts.

It has been held that, following a subsequent absorption of the femoral neck, the nail may become too long. The risk of this is so small that it cannot by any means outweigh the safeguard obtained by this technique against outward slipping.

After impaction of the fracture, the incision is sutured without drainage. The traction is removed immediately. The leg is placed on an ordinary Braun's splint.

This operative technique is, above all, simple. In my material it has been used not by a specialist, but by all the assistants on the service—in all, ten different operators. Most of these had never undertaken a spiking previously.

Since the patient lies relatively comfortably in his bed and since the surgery is done under local anesthesia, one can work at leisure and use as much time as is necessary for an exact carrying out of the procedure. With this technique it is possible to satisfy the two most important requirements for this successful operation: (1) an absolutely exact reduction of the fracture before the nailing and (2) an absolutely exact centering of the nail.

Postoperative Treatment.—The skin sutures are removed on the seventh day. At the same time, the splint is removed and the leg is left free in bed. If the wound has healed, energetic exercise therapy is instituted with active movements in hip, knee, and foot joints.

Generally the patient is kept in bed for eight weeks after the operation. This time has been chosen at Nyström's⁸ suggestion.

It must be assumed that premature weight-bearing may reduce the possibility of entrance of blood vessels from the peripheral fragment through the fracture line to the central fragment.

The nutrition of the central fragment, of course, plays the greatest role for the healing of the fracture and the nutrition of the head of the femur. Theoretically, recumbency for eight weeks without traction should furnish good conditions for such vascularization. Further, the patients as a rule are not harmed by this recumbency. They can move fairly freely in bed and generally require several weeks to obtain mobility of the extremities. After eight weeks' exercise in bed, the mobility generally is very good and the patient may walk relatively well shortly after having been allowed up.

IV. RESULTS

The material is compiled in Table III which comprises all cases admitted into and treated on the Third Surgical Service from March 15, 1935, to Dec. 31, 1937. Roentgenograms of every nailed medial fracture are reproduced in Figs. 13-21. In one case only (Case 33), the x-ray plate was lost. The clinical result in this case is excellent.

The general postoperative reaction has been remarkably slight; in no case threatening. As a rule rises in temperature and pulse have been minimal. Healing of the wound has occurred without serious complications in all of the 117 cases of nailing. In no single case has infection occurred around the nail. In 2 cases only a small hematoma occurred in the subcutaneous layer, 1 of which became injected. After drainage, both these wounds closed with a linear scar.

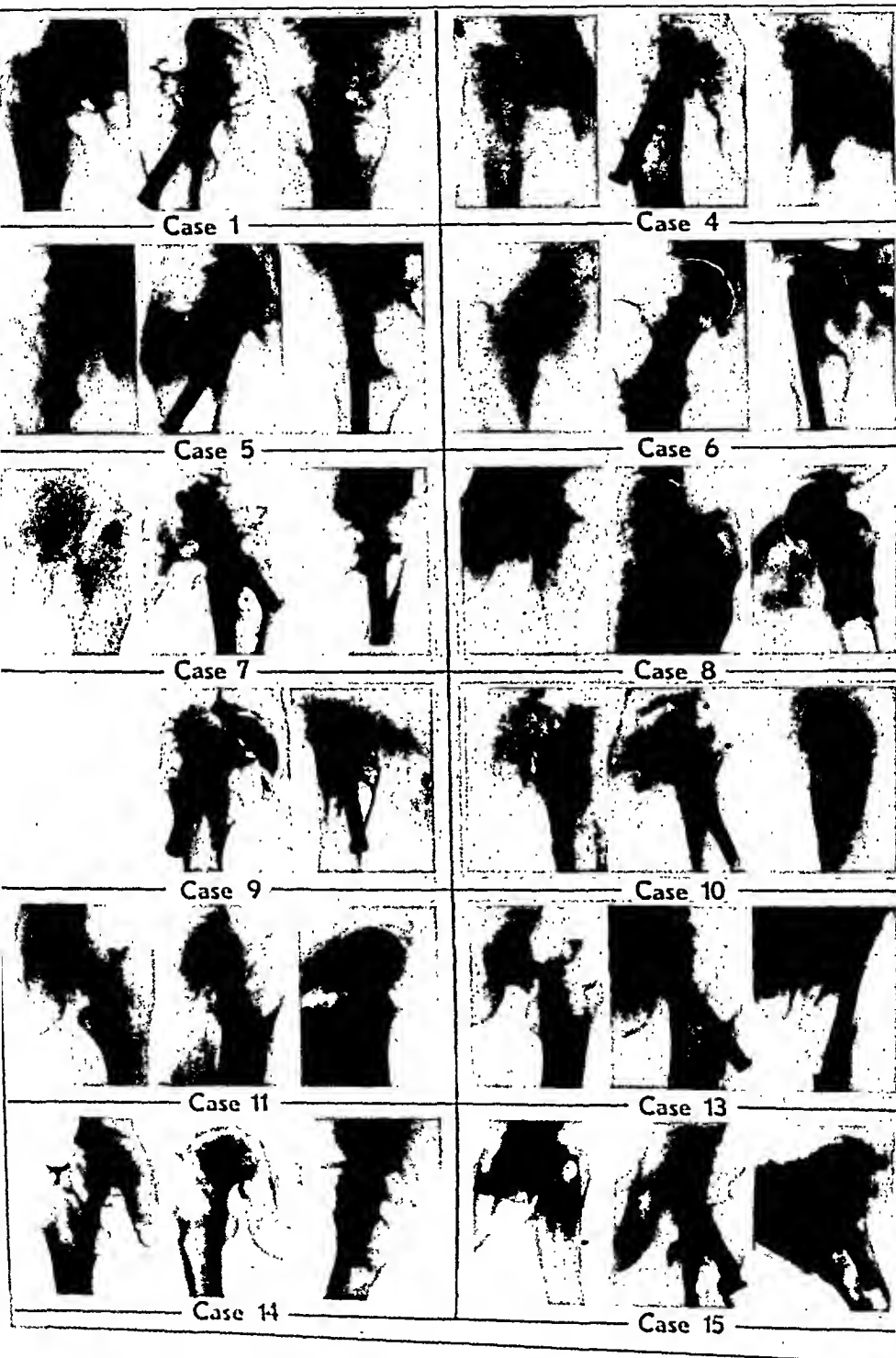


FIG. 15.

FIG. 15-21 (Cases 1-15).—Three films of each case. The first presents the fracture before treatment; the second and third, the two last X-rays.

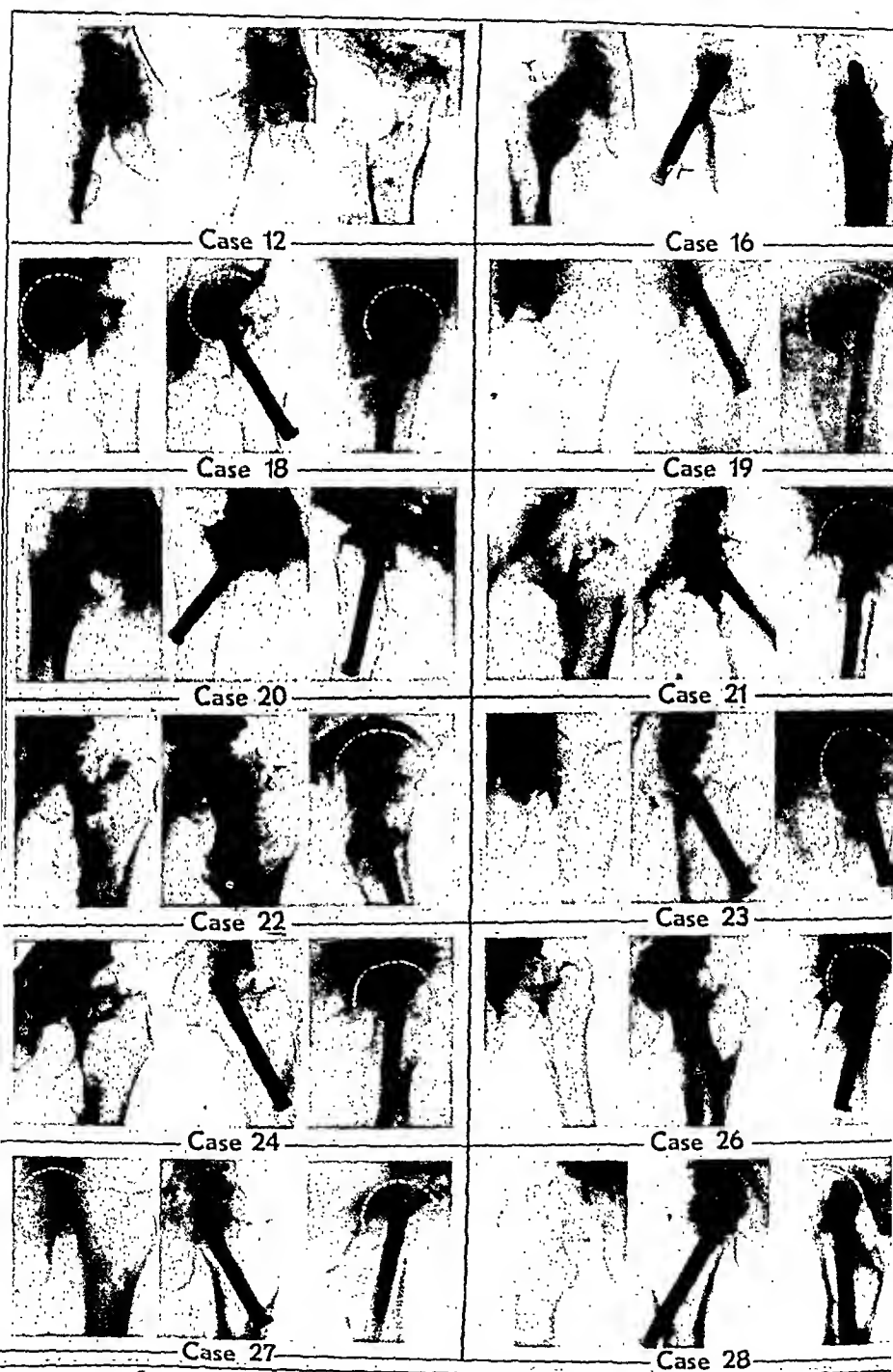


Fig. 14.

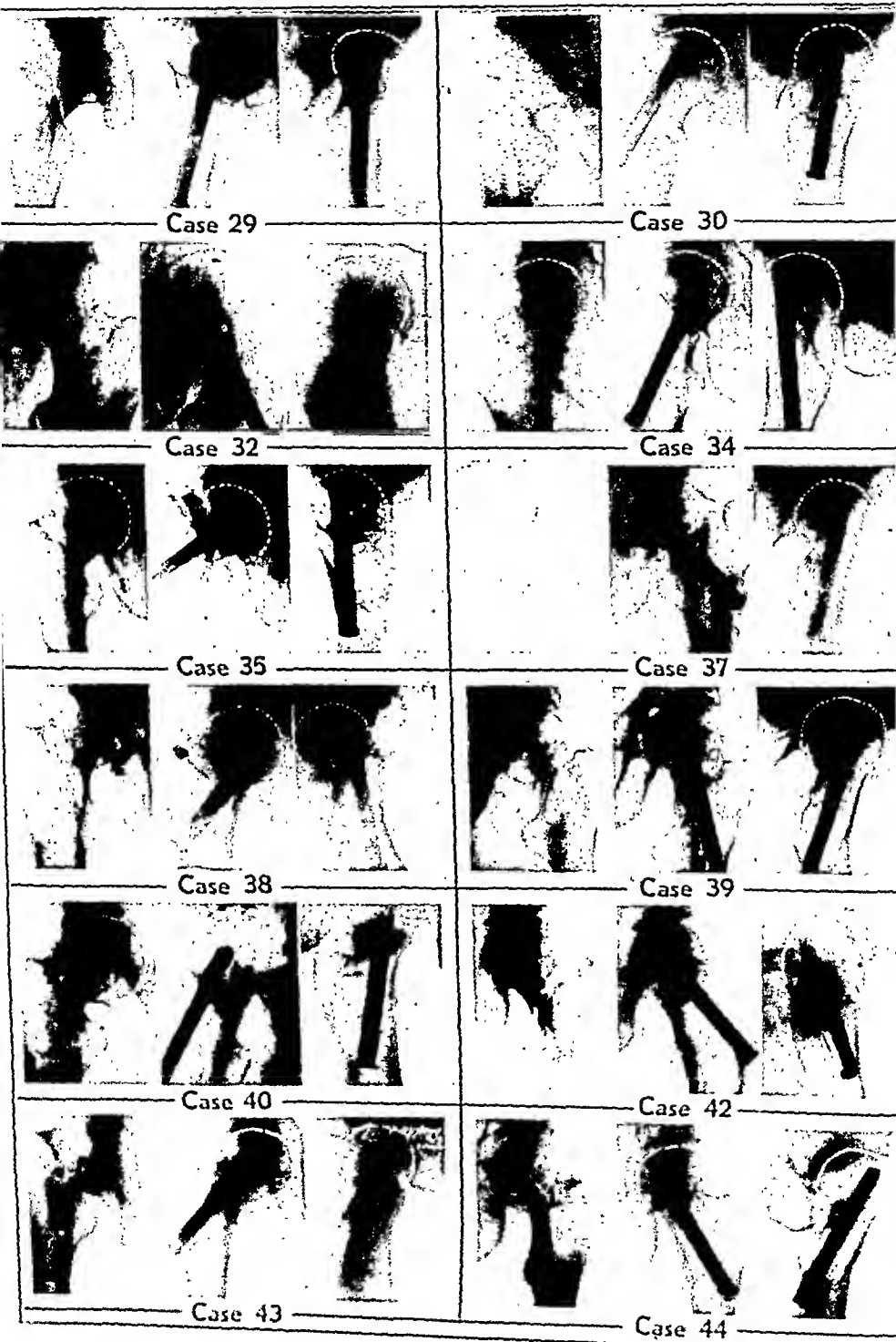


Fig. 15.

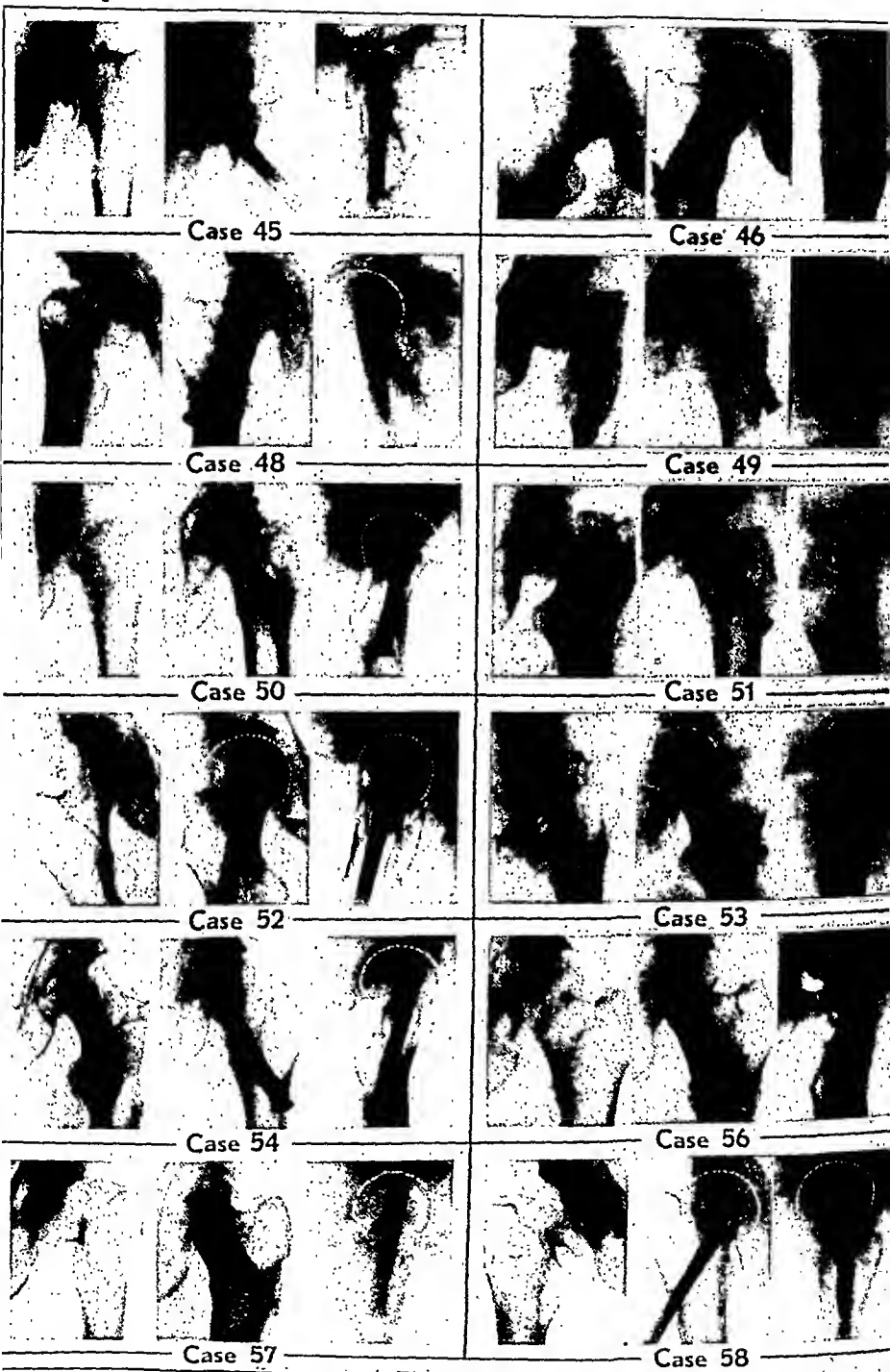


FIG. 16.

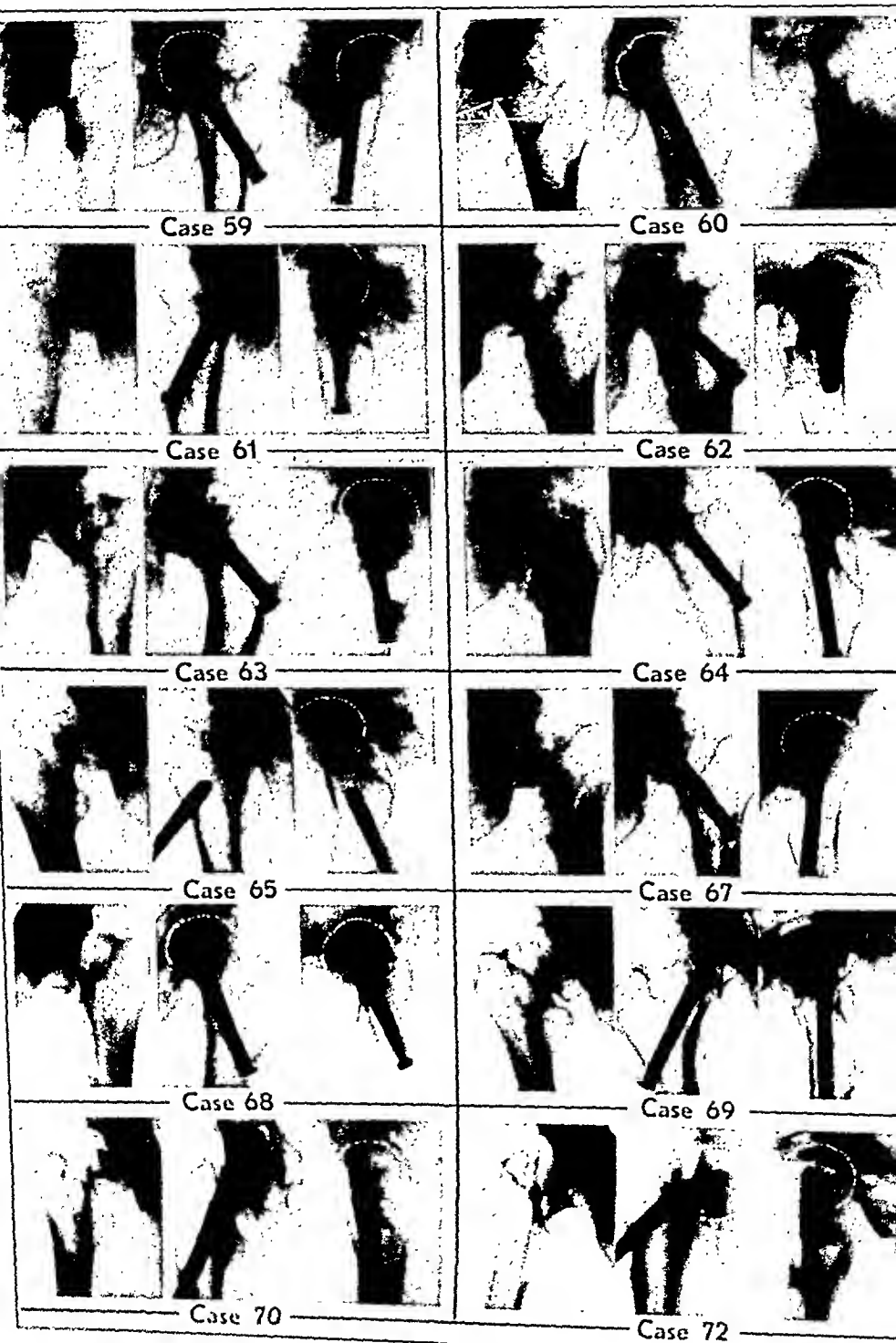


Fig. 17.

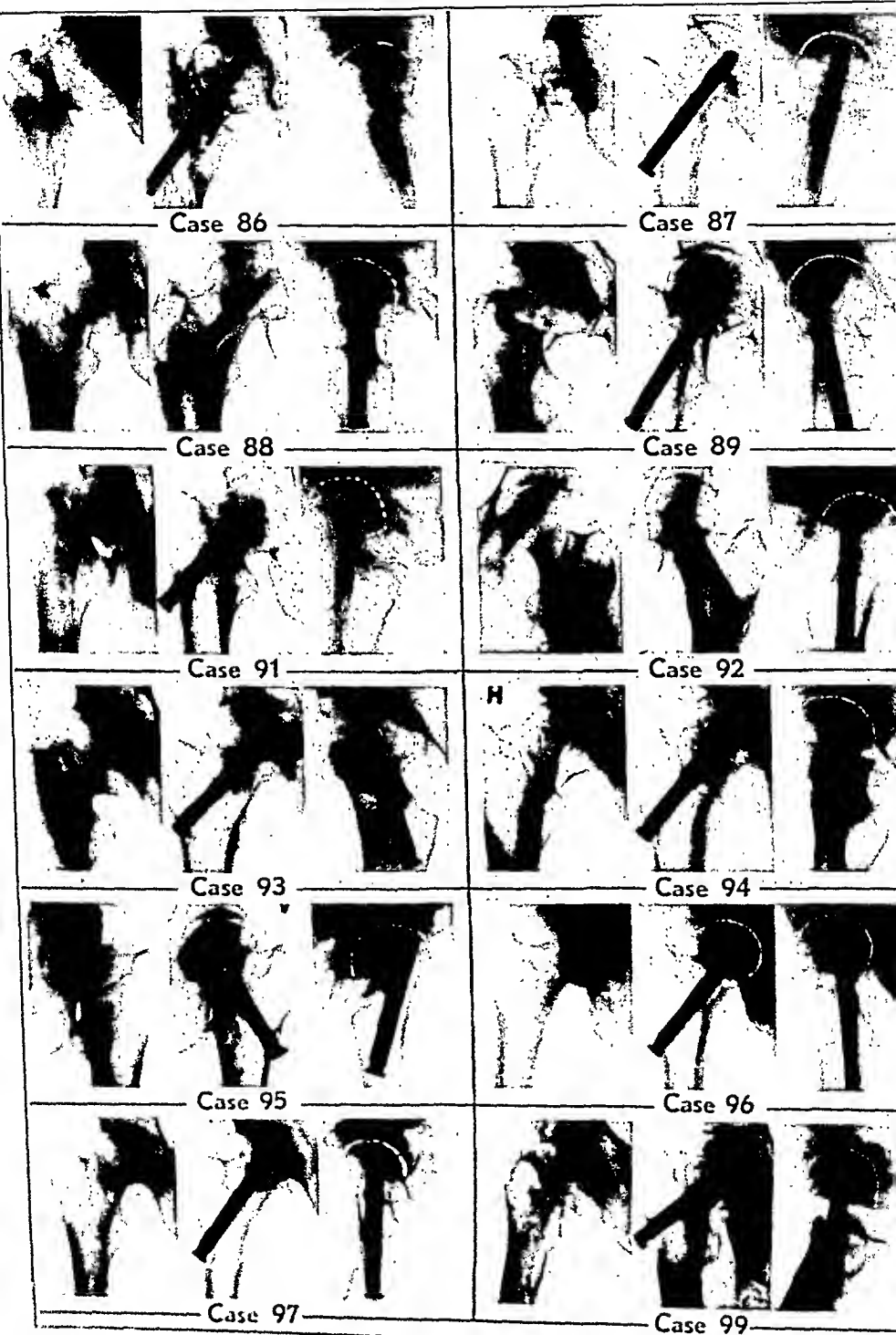


FIG. 13.

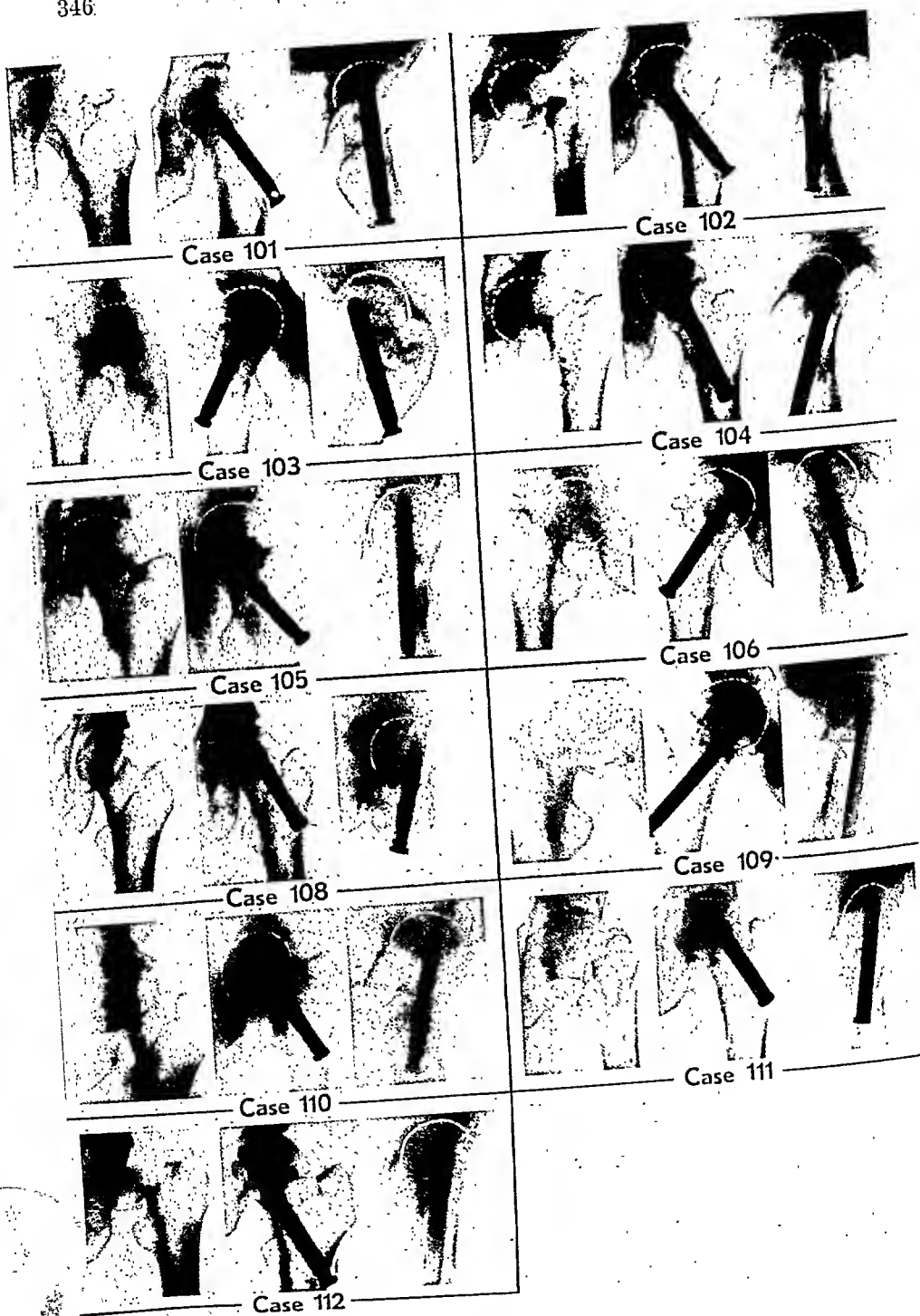


Fig. 20.

These excellent results show that it is practicable to perform this operation with the patient in bed without risk of infection. They also demonstrate that drainage is not necessary in this operation. It has not been applied in any of these cases.

In 1 case in which "wire nailing" was performed and where the wire had been left protruding from the skin ("percutaneous wire nailing"), infection occurred. This method is not used now on the Third Surgical Service just because of the risk of infection.

Thrombosis and embolism have occurred in a total of 9 cases of 117 nailings, of 100 medial fractures in 7 cases, and of 17 lateral fractures

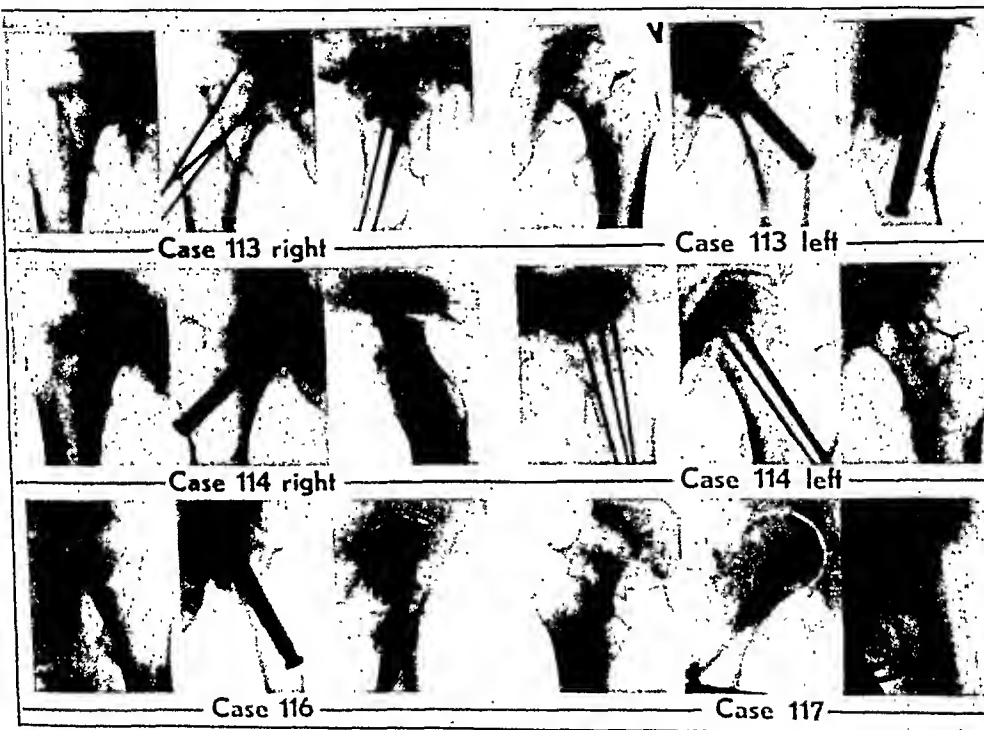


Fig. 21.

in 2 cases. The majority were slight cases which did not seriously affect the general condition. In no case has this complication been fatal.

These figures are surely not greater than those obtained with other methods of treatment of fractures of the femoral neck, quite probably smaller.

MORTALITY

Of 100 nailed medial fractures, 4 cases died within two months after the operation (4 per cent), 3 from bronchopneumonia (Cases 19, 97, 103) and 1 from apoplexy (Case 38). All patients were so ill before the operation that it is highly probable they would have died irrespective of

any treatment they might have received. It is hardly reasonable, therefore, to look upon these deaths as resulting from the operation. One patient died after discharge from the hospital.

This very modest mortality is remarkable for the reason that relatively so many of the patients have been very ill at the time they were nailed. As will appear from the "indications" (see p. 324), 84 per cent and 89 per cent respectively of all medial fractures have been operated upon.

The age of the patients is tabulated in Table II, from which it will be seen that 51 of the patients were more than 70 years of age.

Of 17 nailed lateral fractures, 2 died within two months after the operation, Case 2 from debility (76 years of age), Case 107 from bronchopneumonia (83 years of age). Both were very ill before the operation. One patient died later. These cases cannot be regarded, however, as straight cases of postoperative death.

The relatively low mortality after this operation (6 cases of 117 within two months [5 per cent]) indicates that it is a gentle intervention which is tolerated fairly well by these aged, and frequently very ill, patients.

THE FATE OF THE NAIL

The nail has a tendency to be extruded after a shorter or longer period. Chiseling off of the outer bone lamella of the femur corresponding to the point of introduction of the nail favors such extrusion.

At first (in 1935), when no provisions had been made to affix the nail, it slipped relatively often. In 4 cases the nail slipped out before bony union of the fracture had taken place. In 2 of these cases pseudarthrosis was the result, while the other 2 healed after the nail had been driven in again. In 5 cases the nail was extruded after bony union of the fracture had taken place. The slipping did not then disturb the bony union.

After a special technique had been adopted on the Third Surgical Service to prevent such extrusion, i.e., by driving the lower edge of the nail head inside the edge of the femur, a short slipping has occurred in only 3 cases out of about 95 nailings. This did not, however, have any detrimental effect on the fracture.

The objection has been raised against peripheral fixation of the nail that complications might occur if the neck of the femur were absorbed. The nail then would either penetrate into the joint or it would prevent the fracture surfaces from remaining in contact with each other.

In our material a slight absorption or shortening of the femoral neck has occurred in 9 cases. This corresponds to the so-called primary shortening due to defect at the fracture line. In only 1 case has the nail penetrated 1 to 2 mm. into the joint; this, however, happened because the nail was originally too long, placed immediately under the cartilage. In our material separation of the fracture surfaces as a consequence of the absorption has not occurred, even to a slight degree. This complication, therefore, plays no appreciable role.

Our material shows that it is justifiable and favorable to affix the nail to the edge of the femur by the technique mentioned. It furnishes an effective safeguard against extrusion, which is the chief precaution necessary. If the femoral neck becomes absorbed (shortened), the nail penetrates inward to a corresponding degree. The nail therefore, should not, be driven in more than to within 5 to 8 mm. from the joint surface. Greater shortening of the neck of the femur has not been observed in our material. The danger of penetration into the joint is then negligible.

Our late results prove that the nail head becomes covered by callus. This is favorable also because it protects the soft parts against irritation from the nail. If the nail head protrudes into the soft parts, this may cause formation of a tender, painful bursa, and this may be avoided by using the technique described.

In 3 cases the nail has broken out of the femoral head due to eccentric localization of the nail (Cases 13, 50, and 87). All these cases were renailed with good results.

In 1 case the nail was broken across eight months after the nailing, due to a manufacturing fault in the material. The patient is still under treatment, the fracture fixed by "wire nailing."

HEALING OF THE FRACTURE

As far as the medial fractures are concerned, usually about one year's observation is required to decide the question of bony union. In our material 55 cases have been controlled roentgenographically after a sufficiently long period of observation. Three cases showed deficient union; 2 cases were definite failures; 1 case, doubtful. In an additional 9 cases the patients have written to the effect that they had entirely recovered.

Of 64 cases, 2 (3?) were failures (i.e., less than 5 per cent). As to the remaining cases, the period of observation so far is too short to allow a statement.

The cause of difficulty in these 2 (3?) unsuccessful cases is extrusion of the nail due to a poor grip in 2 of the cases. In the third case, which may improve yet, the cause is delayed union due to inaccurate reduction. In all 3 cases technical errors seem to be chiefly responsible.

Slight absorption (shortening) of the femoral neck is found in 9 cases. In all of these the absorption was slight, from 2 to 5 mm., and played a negligible practical role. According to the roentgenograms in 5 of these cases, the cause seemed to be deficient reduction, particularly deficient impaction at operation, the fracture surfaces being held somewhat apart in their lowest part, or partly the result of a primary defect caused by the fracture itself. In only 1 case was no special cause discoverable.

Table III
100 CASES OF MEDIAL FRACTURES—NAILED

| CASE NO. | AGE SEX | HOSPITAL DAYS | PROOPERATIVE COMPLICATIONS | OPERATION | POST- OPERATIVE COMPLAINT | DATE | GAIT* | PAIN† | ABLE TO WORK‡ | RANGE OF MOTION (DEGREES)** | | | | LAST X-RAY | | CLINICAL RESULTS |
|----------|------------|--------------------------|---|-----------|---------------------------------|---------------------------------------|---------|-------|------------------|-----------------------------|-------------|----------------------|----------------------|-----------------------------------|--|---------------------|
| | | | | | | | | | | ABDUCTION | ADDUCTION | INTERNAL ROTATION | EXTERNAL ROTATION | DATE OF LAST X-RAY (UNION?) | POSITION OF NAIL | |
| 1 | 76 F | 7/18/35 to 9/ 5/35 | Old fracture of the neck of the femur on the opposite side | 7/25/35 | 0 | 6/30/37 | II | + | + | 75° (75) | 45° (45) | 90° (60) | 0° (0) | 6/30/37 Bony | Unchanged | Cured |
| 4 | 87 F | 3/17/35 to 5/ 7/35 | 0 | 3/25/35 | 0 | 12/17/35 (Letter July, 1937) | II | + | + | 40° (120) | 5° (15) | 0° (40) | 0° (60) | 12/17/35 | Nail slipped 2 cm.; reintroduced | Cured |
| 5 | 49 F | 4/24/35 to 6/15/35 | Ankle edema | 4/30/35 | Slight thrombosis | 9/21/37 | I | + | + | N | N | N | 10° (25) | 9/21/37 Bony | Unchanged | Cured |
| 6 | 59 F | 6/15/35 to 8/28/35 | 0 | 6/19/35 | Slight thrombosis | 6/28/37 | I | - | + | N | N | N | N | 6/28/37 Bony | Unchanged | Cured |
| 7 | 64 M | 7/ 5/35 to 8/30/35 | Cerebral syphilis, spinal tubes | 7/18/35 | 0 | 9/ 3/37 | II | + | - | 80° (90) | N | 45° (60) | 10° (15) | 9/3/37 Bony | Unchanged | Cured |
| 8 | 70 F | 6/ 7/35 to 8/31/35 | 0 | 6/19/35 | 0 | 11/25/37 | II | - | + | 60° (100) | 15° (20) | 45° (30) | 0° (30) | 11/25/37 Bony | Unchanged | Cured |
| 9 | 72 F | 3/20/35 to 6/ 8/35 | Renal pathol- ogy, knee in- jury, senility | 4/ 8/35 | Peroneal palsy | 6/ 2/36 | III-IV | + | - | 80° (100) | N | 45° (80) | 10° (30) | 10/2/36 Non- union | Nail slipped after 8 mon. | Poor |
| 10 | 58 M | 4/ 4/35 to 6/ 7/35 | 6 months old fracture | 5/ 7/35 | 0 | 11/ 8/37 | II | + | + | 80° (100) | N | 45° (80) | 10° (30) | 10/26/37 Bony | Nail slipped after 2 yr. | Cured |
| 11 | 78 F | 6/23/35 to 9/ 7/35 | 0 | 7/25/35 | 0 | 12/ 6/37 | III-III | + | - | N | 45° (50) | 20° (45) | 0° (10) | 12/6/37 Bony | Nail slipped after 1½ yr. | Improved |
| 12 | 59 F | 2/ 7/35 to 4/17/35 | 0 | 2/12/35 | 0 | 9/10/36 | I | - | + | N | N | N | Slightly reduced | 9/10/36 Bony | Slipped after 1 yr.; removed | Cured |

*I—Indicates a perfect gait, which cannot be criticized in any way; II—Indicates a very good gait, with negligible discomfort of one kind or another; III and IV—Indicate poor gait or recumbency, respectively.
†N—normal.
‡+—Indicates pain; -—no pain; +-—slight, inconstant pain.
** () —Indicates motion of the other hip joint.

TABLE III.—Cont'd

| | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 |
|-----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|----------------|---------------|---------------|---------------|----------|---------|---------|--------|
| Sex | M | M | M | M | F | M | F | F | F | F | F | F | F | F | F | F | F |
| Age | 11/10/36 | 11/21/36 | 8/8/36 | 10/24/36 | 9/8/36 | 12/5/36 | 5/26/36 | 4/30/36 | 2/23/36 | 5/2/36 | 5/2/36 | 12/21/36 | 5/7/36 | 11/11/36 | 5/13/36 | 1/27/36 | 3/8/36 |
| Per. equio- | | | | | | | | | | | | | | | | | |
| Value, conse- | | | | | | | | | | | | | | | | | |
| Quota bilat- | | | | | | | | | | | | | | | | | |
| erina | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9/17/36 | 9/18/36 | 8/18/37 | 8/24/37 | 9/8/36 | 12/1/37 | 7/1/37 | 9/6/37 | 7/7/37 | 7/8/37 | 9/4/36 | 10/5/37 | 9/15/37 | 9/11/36 | 1/4/38 | | | |
| Fracture of | | | | | | | | | | | | | | | | | |
| Neuralgia | | | | | | | | | | | | | | | | | |
| Fracture of | | | | | | | | | | | | | | | | | |
| lower leg | | | | | | | | | | | | | | | | | |
| 0 | | | | | | | | | | | | | | | | | |
| 9/13 fracture | | | | | | | | | | | | | | | | | |
| of the medial | | | | | | | | | | | | | | | | | |
| tibia | | | | | | | | | | | | | | | | | |
| Tumors | | | | | | | | | | | | | | | | | |
| 0 | | | | | | | | | | | | | | | | | |
| Arteriole- | | | | | | | | | | | | | | | | | |
| toin, fractured | | | | | | | | | | | | | | | | | |
| radial | | | | | | | | | | | | | | | | | |
| Knee injury, | | | | | | | | | | | | | | | | | |
| shortening 2 | | | | | | | | | | | | | | | | | |
| Fracture of | | | | | | | | | | | | | | | | | |
| radius | | | | | | | | | | | | | | | | | |
| Aluminum | | | | | | | | | | | | | | | | | |
| Debil- | | | | | | | | | | | | | | | | | |
| ity | | | | | | | | | | | | | | | | | |
| Fracture mal- | | | | | | | | | | | | | | | | | |
| leolar lateral | | | | | | | | | | | | | | | | | |
| to | | | | | | | | | | | | | | | | | |
| (1929), inter- | | | | | | | | | | | | | | | | | |
| stinal com- | | | | | | | | | | | | | | | | | |
| plaint, debil- | | | | | | | | | | | | | | | | | |
| ity | | | | | | | | | | | | | | | | | |
| 8/26/37 | 8/26/37 | 1/26/37 | 8/24/37 | 9/8/36 | 7/1/37 | 9/7/36 | 7/14/37 | 7/7/37 | 9/4/36 | 10/5/37 | 2/21/36 | 9/11/36 | 1/4/37 | | | | |
| Bony | Bony | Bony | Bony | Bony | Bony | Bony | Bony | Bony | Nonunion | Bony-incipient | (?) | Bony | Bony | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | | | | |
| (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | (10/15) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | | | | |
| 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | | | | |
| (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | (60) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | 60° | | | | |
| (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | (75) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | | | | |
| (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | (80) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | 90° | | | | |
| 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | 110° | | | | |
| (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | (120) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | | | | |
| 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | 45° | | | | |
| (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | 25° | | | | |
| (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | 30° | | | | |
| (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | (30) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | 5° | | | | |
| (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | (5) | | | | |
| N | N | N | N | N | N | N | N | N | N | N | N | N | N | | | | |
| Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | | | | |
| Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | Nail slipped; | | | | |
| reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | reintroduced | | | | |
| Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | Nail broken | | | | |
| through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | through; re- | | | | |
| nail | nail | nail | nail | nail | nail | nail | nail | nail | nail | nail | nail | nail | nail | | | | |
| Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | | | | |
| Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | | | | |
| Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | Unchanged | | | | |

TABLE III.—CONT'D

| FOLLOW-UP EXAMINATION | | | | | | | | | | | | | | | | | |
|-----------------------|------------|----------------------------|---|----------------|---------------------------------|---------------|-------|-------|------------------|-----------------------------|----------------|--------------------------------|-----------------------------------|--|---|----------|---------------------|
| CASE NO. | AGE SEX | HOS- PITAL DAYS | PREOPERATIVE COMPLICA- TIONS | OPERA- TION | POST- OPERATIVE COMPLAINT | DATE | GAIT* | PAIN† | ABLE TO WORK‡ | RANGE OF MOTION (DEGREES)** | | | | INTRIN- SICAL ROTA- TION | LAST X-RAY | | CLINICAL RESULTS |
| | | | | | | | | | | AB- DUC- TION | ADDUC- TION | EXTER- NAL ROTA- TION | DATE OF LAST X-RAY (UNION?) | | POSITION OF NAIL | | |
| 54 | 73 F | 4/30/36 to 7/9/36 | Fracture of arm (1917), arthritis | 6/2/36 | 0 | 12/14/37 | I | + | - | N | 45° (50) | 30° (50) | 20° (30) | 12/14/37 Bony | Unchanged | Cured | |
| 56 | 75 F | 10/13/36 to 12/31/36 | 0 | 12/21/36 | 0 | 7/9/37 | II | +- | + | 90° (100) | N | N | N | 7/9/37 Bony | Unchanged | Cured | |
| 57 | 72 F | 8/1/36 to 10/16/36 | 0 | 8/13/36 | 0 | 11/29/37 | I | - | + | N | N | N | N | 11/29/37 Bony | Unchanged | Cured | |
| 58 | 63 F | 1/27/36 to 3/25/36 | Arthritis | 2/10/36 | 0 | 8/30/37 | II | +- | + | 60° (90) | 30° (60) | 15° (30) | 10° | 8/30/37 Bony; slight shortening of the neck | Nail slipped; removed after 9 mo. | Cured | |
| 59 | 85 F | 1/14/36 to 3/28/36 | Arthritis | 1/20/36 | Thrombosis | 11/18/37 | I | - | + | N | N | N | N | 11/18/37 Bony | Unchanged | Cured | |
| 60 | 33 F | 2/1/36 to 3/28/36 | 0 | 2/5/36 | 0 | July, 1937 | I | - | + | N | N | N | N | 9/4/36 Bony | Unchanged | Cured | |
| 61 | 58 F | 12/20/35 to 3/30/36 | 0 | 1/2/36 | Pulmonary embolism | 7/1/37 | I | - | + | N | N | N | N | 7/1/37 Bony | Unchanged | Cured | |
| 62 | 60 M | 1/22/36 to 4/4/36 | 0 | 2/6/36 | Pulmonary embolism | 12/8/37 | I | - | + | N | N | N | N | 12/8/37 Bony | Unchanged | Cured | |
| 63 | 58 F | 2/5/36 to 4/11/36 | Dyspepsia | 2/10/36 | 0 | July, 1937 | II | + | +- | N | 15° | N | N | 12/1/37 Slight short- ening of neck; union (?) | Unchanged | Improved | |
| 64 | 72 F | 2/5/36 to 4/25/36 | 0 | 2/17/36 | 0 | 6/29/37 | I-II | + | + | 90° | N | N | Reduced | 6/29/37 Bony | Unchanged | Cured | |
| 65 | 50 F | 2/20/36 to 4/30/36 | 0 | 2/29/36 | 0 | 10/13/37 | I | - | + | 90° | N | N | N | 10/14/37 Bony | Nail slipped; removed 10/18/37 | Cured | |

Table III.—Cont'd

[illegible]

TABLE III.—CONT'D

| CASE NO. | AGE SEX | HIS- TORY OFT OFT | PREOPERATIVE COMPLICA- TIONS | OPERA- TION | POST- OPERATIVE COMPLAINT | DATE | GAIT* | PAIN† | ABLE TO WORK‡ | RANGE OF MOTION (DEGREES)** | | | | LAST X-RAY | | CLINICAL RESULTS |
|----------|------------|----------------------------|---|----------------|---------------------------------|------------------------------------|--------|-------|------------------|-------------------------------------|---------------------|----------------|----------------------|---|--|---------------------|
| | | | | | | | | | | ADDUC- TION | ADDUC- TION | EXTEN- SION | INTERNAL ROTATION | DATE OF LAST X-RAY (UNION?) | POSITION OF NAIL | |
| 83 | 55 F | 1/10/37 to 3/13/37 | Neuralgia | 1/11/37 | 0 | July, 1937 | II | + | - | 90° (150) | N | N | 20° (25) | 10/19/37 Bony | Unchanged | Cured |
| 84 | 69 F | 1/15/37 to 3/30/37 | 0 | 1/23/37 | 0 | 8/25/37 | II | - | + | N | N | N | N | 8/25/37 Bony | Unchanged | Cured |
| 85 | 63 F | 1/12/37 to 3/19/37 | 0 | 1/19/37 | 0 | 11/ 2/37 | II | - | - | N | N | N | N | 11/2/37 3 mm. short- ening of neck (?) | 3 mm. inward | Cured |
| 86 | 86 M | 12/24/36 to 1/16/37 | Diabetes, heart disease, debil- ity | 1/ 6/37 | 0 | 11/13/37 (by tele- phone) | III-IV | + | - | 75° (115) | | | | 6/10/37 | Unchanged | Improved |
| 87 | 71 F | 12/ 6/36 to 4/26/37 | Diabetes | 12/31/36 | 0 | 7/26/37 | III | + | - | 30° (60) | Slightly reduced | N | N | 7/26/37 | Nail broken through; re- nailing | Improved |
| 88 | 63 F | 10/24/36 to 1/16/37 | 0 | 10/28/36 | Slight thrombosis | 10/ 8/37 | II | + | - | 90° (100) | 40° (45) | N | N | 10/8/37 Bony | Unchanged | Cured |
| 89 | 73 M | 10/26/36 to 1/23/37 | 0 | 11/9/36 | 0 | 9/ 9/37 | II | + | - | 80° (90) | 40° (50) | N | 5° (10) | 9/9/37 Bony | Nail slipped ½ cm. out- ward | Cured |
| 91 | 79 F | 12/23/36 to 2/26/37 | 0 | 12/29/36 | 0 | 8/ 3/37 | II | + | + | ? | Slightly reduced | 25° (35) | 20° (60) | 8/3/37 ½ cm. short- ening of neck | Nail ¼ cm. out | Cured |
| 92 | 52 F | 12/23/36 to 3/ 3/37 | 0 | 1/ 4/36 | 0 | 6/28/37 | II | - | + | Slightly reduced (3 to 5°) | N | N | 45° (60-70) | 6/28/37 Bony | Unchanged | Cured |
| 93 | 63 M | 1/ 4/37 to 3/ 6/37 | 0 | 1/15/37 | 0 | 6/23/37 | II | + | - | N | N | N | N | 6/29/37 | Unchanged | Cured |

TABLE III.—Cont'd

| CASE NO. | AGE SEX | HOSPITAL DAYS | PREOPERATIVE COMPLICATIONS | OPERATION | POST- OPERATIVE COMPLAINT | DATE | CARE* | PAIN† | ABLE TO WORK‡ | RANGE OF MOTION (DEGREES)** | | | | LAST X-RAY | | CLINICAL RESULTS |
|----------|------------|----------------------------|---|-----------|---------------------------------|----------|--------|-------|------------------|-----------------------------|-----------|----------------------|----------------------|-----------------------------------|---------------------|--|
| | | | | | | | | | | ABDUCTION | ADDUCTION | INTERNAL ROTATION | EXTERNAL ROTATION | DATE OF LAST X-RAY (UNION?) | POSITION OF NAIL | |
| 109 | 64 M | 9/ 7/37 to 10/19/37 | 0 | 10/ 7/37 | 0 | 11/20/37 | In bed | - | | | | | | 11/20/37 | Unchanged | ? |
| 110 | 79 F | 10/26/37 to 11/27/37 | Apoplexy 3 yr. ago | 11/11/37 | | 12/ 4/37 | In bed | - | | | | | | 11/18/37 | | ? |
| 111 | 82 F | 10/19/37 to 11/17/37 | Cerebral hemorrhage 7/15/37 | 11/ 4/37 | 0 | 11/17/37 | In bed | - | | | | | | 12/28/37 | Unchanged | ? |
| 112 | 78 F | 11/ 6/37 to 12/ 7/37 | 0 | 11/8/37 | 0 | 12/ 7/37 | In bed | - | | | | | | 12/28/37 | Unchanged | ? |
| 113 | 74 F | 11/14/37 to 12/ 2/37 | Fracture of neck of femur on the opposite side 2 yr. ago. | 11/19/37 | 0 | 12/ 2/37 | In bed | | | | | | | 1/4/38 | Unchanged | Fracture on opposite side; complete cure, wire fixation |
| 114 | 79 F | 9/25/37 to 10/13/37 | Fracture of neck of femur on opposite side 2 yr. ago | 10/ 5/37 | 0 | 10/13/37 | In bed | | | | | | | 12/2/37 | Unchanged | Fracture on opposite side cured by wire fixation |
| 116 | 80 F | 12/18/37 to 1/ 7/38 | Debility, senility | 12/21/37 | 0 | 1/ 1/38 | In bed | | | | | | | 12/28/37 | Unchanged | ? |
| 117 | 75 F | 11/18/37 to 1/11/38 | 0 | 12/ 1/37 | 0 | 1/ 1/38 | In bed | | | | | | | 12/1/37 | Unchanged | ? |

Shortening of the femoral neck, therefore, sometimes appears to be the result of errors in technique, particularly with regard to the reduction. Our material demonstrates that an accurate reduction and good impaction generally prevent shortening of the neck of the femur. This complication, therefore, plays a quite subordinate part in our material.

Necrosis of the femoral head has been brought forward as an argument against nailing. The typical necrosis (one to two years after successful nailing) has not been demonstrated in a single case in our material.

In one case partial necrosis occurred after malposition of the fracture due to extrusion of the nail (Case 9). This was explained, however, as caused directly by the malposition, and the deficiency of nutrition of the femoral head resulting from this. In another case (Case 50) abundance of calcium in the head of the femur one and one-fourth years after nailing indicates deficient nutrition. Pronounced necrosis was not found, however.

The period of observation of the majority of our cases has been too brief to enable us to evaluate the incidence of this complication. According to our present experience, it appears to play a very subordinate role.

It is theoretically probable that the nutrition of the femoral head in some degree depends upon the nutrition from the peripheral fragment.

An accurate reduction and good immobilization of the fracture, for example, during eight weeks' recumbency without traction, should favor vascularization through the fracture line.

The good results obtained in our material by this procedure may support this possibility. Of the 17 nailed lateral fractures all the surviving patients obtained bony union within three to four months.

CLINICAL RESULTS

Pain in the leg is present, chiefly when there is unsuccessful union. With successful bony union, slight pain and slight discomfort are not unusual, but these are not particularly embarrassing (Table III). Ability to work has been recorded in the table. In these old patients it is of fairly subordinate consequence. The gait has been judged according to estimate: I indicates a perfect gait, which cannot be criticized in any way, and this is found in a total of 26 cases. II indicates a very good gait, with negligible discomfort of one kind or another, in a total of 51 cases. III and IV indicate poor gait or recumbency, respectively, in a total of 9 cases.

Of the total of 100 cases of medial fractures in our material 9 are still under treatment and 5 have died. Of the remaining 86 patients, 77 have excellent or good gait (90 per cent).

Regarding the end results, it is as yet too early to make any definite statement, because a considerable number of the cases has been observed for too short a time.

TABLE III.—Cont'd

| CASE NO. | AGE SEX | HIS- TORY DAYS | PREOPERATIVE COMPLICA- TIONS | OPERA- TION | POST- OPERATIVE COMPLAINT | DATE | GAIT* | PAIN† | ABLE TO WORK† | RANGE OF MOTION (DEGREES)** | | | | DATE OF LAST X-RAY (UNION?) | LAST X-RAY POSITION OF NAIL | CLINICAL RESULTS |
|----------|------------|----------------------------|---|----------------|---------------------------------|----------|--------|-------|------------------|-----------------------------|----------------|----------------|----------------------|-----------------------------------|-----------------------------------|--|
| | | | | | | | | | | FLXION | ADDUC- TION | ADDUC- TION | INTERNAL ROTATION | | | |
| 109 | 64 M | 9/7/37 to 10/19/37 | 0 | 10/7/37 | 0 | 11/20/37 | In bed | - | | | | | | 11/20/37 | Unchanged | ? |
| 110 | 79 F | 10/26/37 to 11/27/37 | Apoplexy 3 yr. ago | 11/11/37 | | 12/4/37 | In bed | - | | | | | | 11/18/37 | | ? |
| 111 | 82 F | 10/19/37 to 11/17/37 | Cerebral hemor- rhage 7/15/37 | 11/4/37 | 0 | 11/17/37 | In bed | - | | | | | | 12/28/37 | Unchanged | ? |
| 112 | 78 F | 11/6/37 to 12/7/37 | 0 | 11/8/37 | 0 | 12/7/37 | In bed | - | | | | | | 12/28/37 | Unchanged | ? |
| 113 | 74 F | 11/14/37 to 12/2/37 | Fracture of neck of femur on the oppo- site side 2 yr. ago. | 11/19/37 | 0 | 12/2/37 | In bed | | | | | | | 1/4/38 | Unchanged | Fracture on opposite side; com- plete cure, wire fixa- tion |
| 114 | 79 F | 9/25/37 to 10/13/37 | Fracture of neck of femur on opposite side 2 yr. ago | 10/5/37 | 0 | 10/13/37 | In bed | | | | | | | 12/2/37 | Unchanged | Fracture on opposite side cured by wire fixation |
| 116 | 80 F | 12/18/37 to 1/7/38 | Debility, senil- ity | 12/21/37 | 0 | 1/1/38 | In bed | | | | | | | 12/28/37 | Unchanged | ? |
| 117 | 75 F | 11/18/37 to 1/11/38 | 0 | 12/1/37 | 0 | 1/1/38 | In bed | | | | | | | 12/1/37 | Unchanged | ? |

THE RELIEF OF PAROXYSMAL HYPERTENSION BY EXCISION OF PHEOCHROMOCYTOMA

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INTRODUCTION

A NUMBER of reports of pheochromocytomas (paragangliomas) have now accumulated in the literature. The majority of the recorded cases were of post-mortem examinations. However, in recent years the clinical recognition of these neoplasms has been possible because of the realization of their causal relationship to paroxysmal hypertension. Vaquez and Donzelot were the first to diagnose such a tumor in vivo and this was not until 1926. A review of the clinical syndrome and of the histopathology of these neoplasms would be needless repetition here in view of the several adequate articles already published (Rabin, Belt and Powel).

On the other hand there is not a great deal of recorded operative experience in the treatment of these neoplasms nor have many studies on their adrenalin content been made. With the purpose of emphasizing these points, the following case is recorded.

CASE REPORT.—F. K. (No. 169122), white female, 41 years of age, admitted to the Medical Service of Dr. George F. Dick, March 28, 1937, complaining of "attacks" that are characterized as follows: A feeling of constriction in the head, then the chest which induces marked labored breathing; palpitation and tachycardia, pain in the midportion of the abdomen, nausea and often vomiting. By this time there is a sensation of marked weakness and then purposeless movements of the arms and legs, mostly on the right, which however can be voluntarily controlled. No loss of consciousness. There is no fecal or urinary incontinence. Following the attack the patient feels exhausted for one to two hours.

The attacks have been experienced for the past eight years and with increasing frequency until at present there is almost one attack a day. The patient states that for a period of 1 to 2 minutes she can "feel them coming on." There is no special cause assigned to them but a "start" has often initiated them. The patient feels they are more common 1 to 1½ hours after meals.

Past personal and family histories are irrelevant.

Physical examination reveals a well-developed and nourished white female. Objective findings are negative. Pulse, 110; respiration, 20; blood pressure, 146/98; blood and urinalysis, negative; Wassermann and Kahn, negative; electrocardiogram, sinus arrhythmic; roentgenograms of chest, negative. The heart is not enlarged.

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Of the total of 100 cases of medial fractures, 5 have died; 2 cases, possibly 3, have failed as to end results and the remainder are cured or improved.

Bilateral nailing of medial fractures has been performed in 2 cases (Case 113 and Case 114); i.e., "wire nailing" on one side and ordinary nailing on the other side. The results are good.

Of 17 lateral fractures, 3 have died; the remainder have been cured or improved.

SUMMARY

A simple and gentle method is presented for reducing and nailing fractures of the femoral neck. The reduction is performed with wire traction on a specially constructed splint, which permits extensive internal rotation. The result of the reduction is ideal in 98 per cent of the cases.

The traction treatment permits preliminary treatment of the patient prior to the operation and observation of the patient with a view to indication for and selection of a favorable time for nailing.

The leg is kept lying in unchanged position on a splint until after the nailing is completed. The nailing is carried out while traction is maintained and with the patient lying in bed under local anesthesia.

In order to ensure an accurate centering of the nail, a special sighting apparatus has been constructed for the aiming of the wire and the nail in two planes.

This procedure permits reduction as well as operation on very ill patients. Eighty-four to 89 per cent of all medial fractures have been so treated, a total of 100 operations in the course of three years. The results show that 2 per cent died within two months after the operation. Only 2 (3?) were failures as far as fixation of the fracture is concerned. Bilateral nailing was used in 2 cases. Of 38 lateral fractures, 17 were nailed by the same method. Two died within two months. Bony union occurred in all the surviving cases.

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localization of the tumor is possible by pneumoretroperitoneography for the following reasons: (1) Multiple tumors may be present and the lumbar incision would not permit thorough exploration of the retroperitoneal spaces. (2) There may be congenital absence of one adrenal

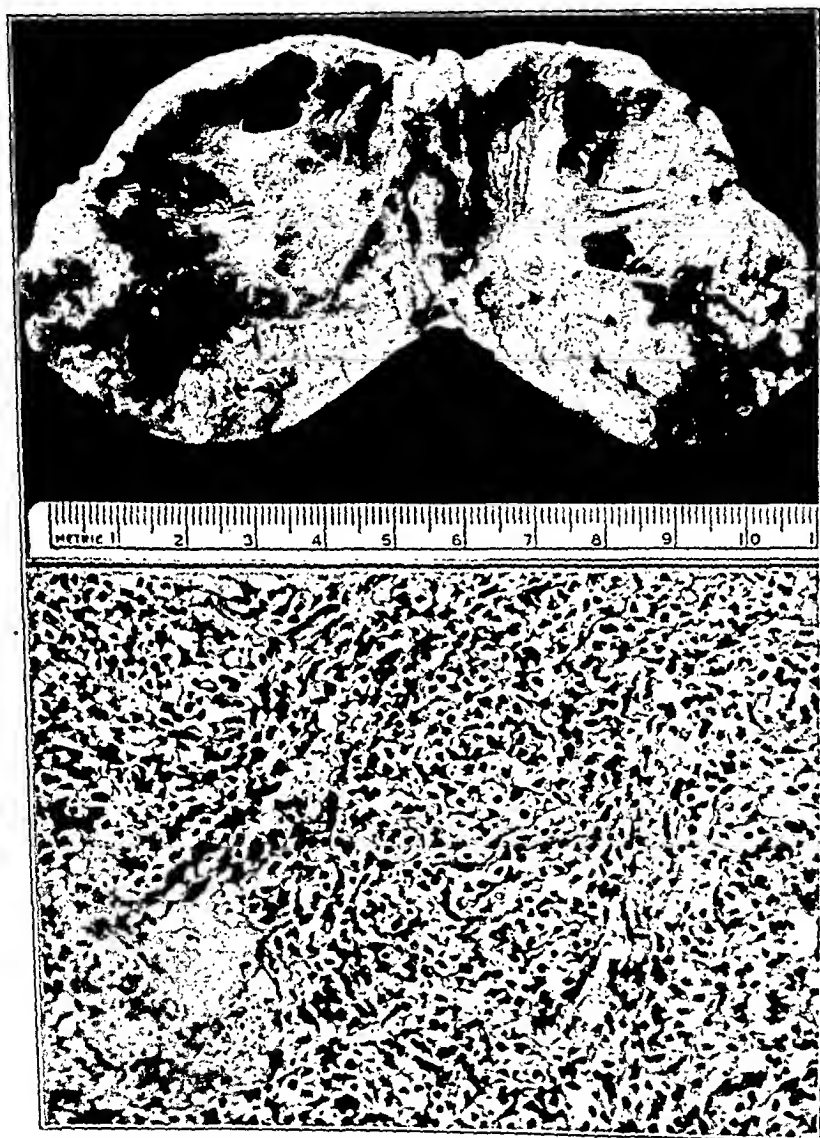


Fig. 3.—Gross and microscopic appearances of excised pheochromocytoma.

gland. (3) Where, as in some reported instances, the tumor is on the anterior aspect of the kidney and adherent to surrounding tissues, sparing this kidney would be more feasible from an anterior approach than through a lumbar incision.

In places they appear as huge processed syncytium-like masses with giant nuclei. In other regions the cells strongly resemble those of the normal suprarenal medulla and elsewhere those of the adrenal cortex, with typical vacuolated cytoplasm. In some fields the cells appear to have been markedly compressed into fusiform shape by surrounding blood-filled sinusoids. In general the nuclei are rounded or oval with finely divided chromatin and one nucleolus. The cytoplasm is eosinophilic and finely granular. The appearance after chromate fixation is striking. Almost all of the tumor cells—even the vacuolated ones—show either diffuse browning of their cytoplasm or brown granulations. There is considerable extravascular browning of stroma and of the precipitate in blood vessels. A few coarse brownish hyaline granules (not seen in formalin-fixed sections) are present both in and outside tumor cells.

A section through the thick hyaline capsule shows a narrow rim of what appears to be atrophic adrenal cortex, outside the capsule. While these cells are not unlike some of the tumor cells, there is absolutely no chromaffinity, although the tumor

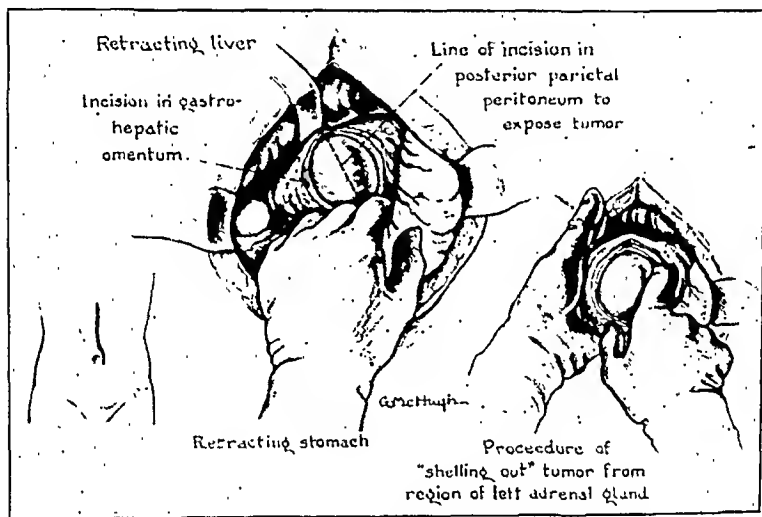


Fig. 2.—Semidiagrammatic illustration of excision of left suprarenal pheochromocytoma through gastrohepatic omentum.

cells on the inside of the capsule are deeply browned. One section shows a recent fibrin thrombus in a large blood space and scattered foci of necrosis in the tumor.

Pathologic diagnosis: Pheochromocytoma, left adrenal gland.

Operative Procedures.—Eleven previous instances of pheochromocytoma have been reported to date in which operative removal was successful and was followed by relief of the "attacks." These cases are summarized in Table I. Case 9 is recorded as pheochromocytoma because of the positive histologic findings (positive chromate reaction), but from the clinical history there were no paroxysmal attacks of hypertension. This patient presented a persistent "hypertension" of 190 to 160 systolic pressure. Of 10 cases (that of von der Muhl not included) 6 were removed through a lumbar or kidney incision and 4 through abdominal incisions. In our opinion it would appear that the abdominal incision has advantages over the lumbar incision even though accurate

TABLE I—Cont'd

| 6. Kalk, H. (1934) | Female, aged 36 years: right supra-renal region previously explored; tumor at upper pole of right kidney, "adrenal vessels" going to it | Normal blood pressure readings during and following operation | Recovery from operation although complicated by right-sided pneumonia and parotitis |
|--|---|---|---|
| 7. Leriche, R. (1934) | Male, aged 41 years: right supra-renal region previously explored; left kidney incision to removal of cherry-sized tumor from retro-peritoneal fat above left kidney | Before anesthesia 220/135; during excision of tumor, 240/150; during closure of wound, 160/100; during convalescence, 140/100 | Uneventful; no recurrence of attacks |
| 8. Von der Muhl (1934) | Reference not available; quoted by Belt and Powell. | Not reported | Convalescence prolonged due to "hypochromic anemia," and persistent suppurative fistulous tract; blood pressure 98/48 |
| 9. McKenna, C. M., and Hines, L. E. (1935) | White female, aged 59 years: right lumbar incision to removal of right kidney with tumor 12 by 9 cm. connected to upper pole and densely adherent to surrounding structures; no typical attacks of paroxysmal hypertension reported; blood pressure was 190 to 160 systolic | | Uneventful; blood pressure remained normal |
| 10. Kelly, H., Piper, M., Wilder, R., and Walters, W. (1936) | Female, aged 37 years: right posterolateral (kidney) incision for removal of tumor mass 10.5 cm. in diameter invading suprarenal gland | "At the onset of the operation the blood pressure was normal and there was little variation during the time of operation," | Postoperative course uneventful; blood pressure 125/85 |
| 11. Boer, E., King, F. H., and Prinzmetal, M. (1937) | Female, aged 26 years: left lumbar incision to removal of spheroidal tumor 9 cm. in diameter occupying region of left adrenal gland, pushing kidney downward | No rise in blood pressure during operation but at one time systolic pressure fell to 80 cm. | |

TABLE I
SUMMARY OF SUCCESSFUL EXCISIONS OF PNEUROMYOTOMAS REPORTED UP TO 1937

| CASE | AUTHOR | PROCEDURE | BLOOD PRESSURE DURING OPERATION | POSTOPERATIVE COURSE |
|------|--|---|---|--|
| 1. | Mayo, C. H. (1927) | Female, aged 30 years: upper midline incision to removal of tumor 6 by 4 cm. behind tail of pancreas on mesial side of left kidney | Not reported | Relief from "attacks"; convalescence uneventful except pulmonary infarction which developed two weeks after operation and lasted for 10 days; recovery |
| 2. | Shipley, A. M. (1929) | Female, aged 26 years: first operation high left rectus incision, tumor palpated anterior to upper pole of right kidney and was not removed; second operation, incision coursing below right costal arch to removal of tumor mass 8 cm. in diameter | Variation from 130 to 140 systolic; no "attacks" during operation; fall to 88/62 after tumor was removed | Relieved of symptoms; last report 10 months after operation |
| 3. | Porter, M. F., and Porter, M. F., Jr. (1930) | Male, aged 39 years: midline incision converted into T-shaped incision for removal of mass on anterior aspect of right kidney | Systolic pressure 110 at beginning, rose to 264, and dropped to 78 toward end of operation when adrenalin was given | Well for 74 days; no further note |
| 4. | Suermondt, W. F. (1934) | Male, aged 29 years: "fist-sized" tumor removed from upper pole of right kidney through loin incision | Fall of blood pressure during operation to a "very low level" (75-60 systolic); no other readings recorded | Recovery from operation and free from attacks during six months following it |
| 5. | Coller, F. A., Field, H., and Durant, T. M. (1934) | Male, aged 16 years: small midline incision to permit palpation with finger; incision then enlarged to removal of mass 8 cm. in diameter from anterior aspect of right kidney | Blood pressure 150/120 at beginning and rose to 300/140 after one hour; shortly after removal of tumor, fell to where no reading could be obtained; after recovery from operation, 130/90 | Followed for 6 months; no recurrence of attacks |

TABLE 1—Cont'd

| | | Normal blood pressure readings during and following operation | Recovery from operation although complicated by right-sided pneumonia and parotitis |
|--|---|---|---|
| 6. Kalk, H. (1934) | Female, aged 36 years: right loin incision to removal of fist sized tumor at upper pole of right kidney, "adrenal vessels" going to it | | |
| 7. Leriche, R. (1934) | Male, aged 41 years: right suprarenal region previously explored; left kidney incision to removal of cherry-sized tumor from retroperitoneal fat above left kidney | Before anesthesia 220/135; during excision of tumor, 240/150; during closure of wound, 160/100; during convalescence, 140/100 | Uneventful; no recurrence of attacks |
| 8. Von der Muhl (1934) | Reference not available; quoted by Belt and Powell. | Not reported | Convalescence prolonged due to "hypochromic anemia," and persistent suppurative fistulous tract; blood pressure 98/48 |
| 9. McKenna, C. M., and Hines, L. E. (1935) | White female, aged 59 years: right lumbar incision to removal of right kidney with tumor 12 by 9 cm. connected to upper pole and densely adherent to surrounding structures; no typical attacks of paroxysmal hypertension reported; blood pressure was 190 to 160 systolic | | |
| 10. Kelly, H., Piper, M., Wilber, R., and Walters, W. (1936) | Female, aged 37 years: right posterolateral (kidney) incision for removal of tumor mass 10.5 cm. in diameter invading suprarenal gland | "At the onset of the operation the blood pressure was normal and there was little variation during the time of operation" | Uneventful; blood pressure remained normal |
| 11. Beer, E., King, F. H., and Prinzmetal, M. (1937) | Female, aged 26 years: left lumbar incision to removal of spheroidal tumor 9 cm. in diameter occupying region of left adrenal gland, pushing kidney downward | No rise in blood pressure during operation but at one time systolic pressure fell to 80 cm. | Postoperative course uneventful; blood pressure 125/85 |

The Blood Pressure During Operation.—In 9 cases of the above series, including the one reported here, blood pressures were observed at frequent intervals during the removal of the growth. In 4 no rise was noted at any time during the operation; in 4 there was a rise to well above 200 systolic (as observed during attacks preoperatively) when the tumor was manipulated and removed and then rapidly fell to a level at which readings could not be obtained for a short period when a return to approximately 70 to 90 was then recorded (therapeutic measures to combat shock were of course instituted). In Leriche's case the pressure had risen to an "attack level" after induction of anesthesia but fell to an unmeasurable level when the small tumor was removed.

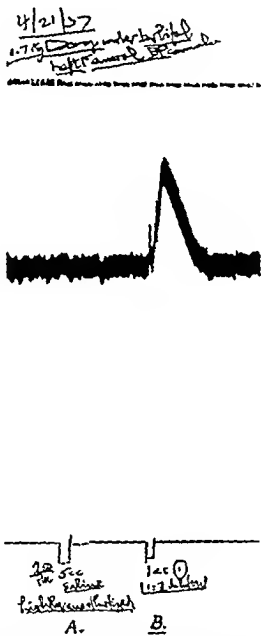


Fig. 4.—Tracing of blood pressure of 10.7 kg. dog under barbitol anesthesia. *A.*, injection of 5 c.c. saline solution intravenously; no perceptible effect on blood pressure. *B.*, injection of 1 c.c. dilute HCl extract of pheochromocytoma; rapid rise in blood pressure for brief period, a "typical adrenalin curve" (experiment performed by Dr. Louis Leiter).

Analysis of the Tumors for Adrenalin.—The origin of these neoplasms from chromaffin tissue has led to a study of their adrenalin content. Table II summarizes the more recent observations.

In normal adrenal glands there is approximately 1 to 2 mg. of adrenalin per gram of tissue. In the above series such values were obtained for some tumors while very high values, such as 20 to 40 mg., were obtained in others. Various factors might account for small variations in the results of analyses, such as inclusion in the assayed tissue of portions of normal adrenal medulla and cortex. On the other hand, the

TABLE II
SUMMARY OF ANALYSES OF PHEOCHROMOCYTOMAS FOR ADRENALIN

| AUTHOR | SPECIMEN | CHEMICAL METHOD OF ANALYSIS | ADRENALIN CONTENT OF TUMOR |
|---|--|--|----------------------------|
| Rabin (1929) | Tumor from autopsy 40 gm. | Folin (colorimetric) | 1.5 mg. per gm. |
| Belt and Powell (1934) | Tumor from autopsy 1,000 gm. | Folin | 20 mg. per gm. |
| Kalk (1934) | Tumor and kidney tissue surgical specimen | Zanfrotnini | 30 to 40 mg. per gm. |
| Burgess, A. M. (1936) | Tumor from operation (died post-operatively) | Folin | 3.5 mg. per gm. |
| Kelly, et al. (1936) | Tumor from operation 240 gm. | Folin | 1 mg. per gm. |
| Popken, C. (1936) | Tumor from autopsy 6 by 5 by 4 cm. | Pharmacologic method? Effect on blood pressure of decerebrated cat | 9 mg. per gm. |
| Fein and Carman (1937) | Tumor from autopsy; weight not stated | Not stated | 22 mg. per gm. |
| Edwards (1937) | Tumor from autopsy 20.7 gm. | Folin | 3.94 mg. per gm. |
| Humphreys (1937) | Tumor from autopsy 35 gm. | Folin | 2.5 to 3 mg. per gm.* |
| (Unpublished case from University of Chicago Clinics) | | | |
| Brunschwig, Humphreys, and Roome (1938) | Tumor removed at operation, 75 gm. | Folin | 1.25 mg. per gm.* |

*Adrenalin determinations were made by Dr. J. M. Rogoff, of the Department of Physiology.

very high values, if true, would indicate a marked hyperactivity on the part of the neoplastic cells in the production of adrenalin.

There is no apparent explanation for the paroxysmal character of the attacks of hypertension. That such attacks are due to sudden outpouring of an excess of adrenalin is inferred from the excess of adrenalin producing tissue represented by the tumor and by the relief from such attacks following removal of these tumors. Final confirmation of this is afforded by the observation of Beer, King, and Prinzmetal, who demonstrated a pressor substance (adrenalin) in the blood of a patient during an attack.

A possible explanation for the paroxysmal nature of the attacks is that the secretion of adrenalin by the tumor is controlled to some extent by the same mechanism which controls the secretion from the normal

adrenal glands and that when such a mechanism calls for a sudden release of adrenalin into the circulation the tumor tissue also responds.

SUMMARY

A review is made of the eleven cases of paroxysmal hypertension due to retroperitoneal pheochromocytoma in which successful operative removal resulted in relief from symptoms. An additional case is recorded.

Experience has shown that such tumors are eventually fatal, even though not malignant, because of the repeated hypertensive attacks with ultimately a very severe one with fatal collapse. Sufficient experience has been gained to permit the recognition of these tumors by the characteristic clinical syndrome and such a diagnosis should indicate operative removal of the tumor. The repeated successes of the latter modify the previous pessimistic prognosis held for such cases.

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TWO CASES OF MALIGNANT PERINEAL TUMOR SIMULATING INFLAMMATORY LESIONS

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CARCINOMA of the perineum, with the exception of epidermal neoplasms, is exceedingly rare, and, because of its rarity, we believe a report of two cases is indicated. During the past two years we have had the opportunity of studying two highly malignant primary perineal tumors which simulated inflammatory lesions. We have been unable to discover any description of a similar growth by personal inquiry or by a fairly exhaustive review of recent and past literature. Less than a dozen cases of malignant perineal tumors have been reported in adults and these consist of squamous cell carcinoma, sarcoma, and adenocarcinoma. A survey of the standard textbooks of pathology and surgery has afforded scanty, if any, pertinent information concerning these peculiar lesions. In general, all types of malignant tumors of the perineum are remarkable for their infrequency; however, it is conceivable that their frequency is greater than the statistics would indicate. The two cases reported here are the only cases of this nature in 113,922 admissions at the University Hospitals of Cleveland in the period from 1923 to 1937.

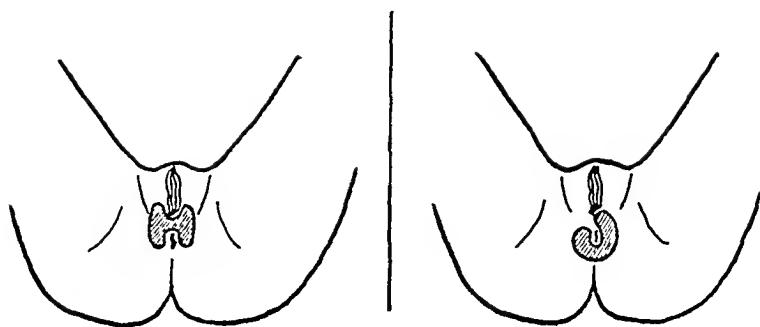
At the time the patients were first examined, the outstanding features of both cases were pain, the evidences of inflammation, and the short duration of the lesions. We wish to emphasize their symptomatology, clinical course, similarity, and type. These tumors must be differentiated from acute or subacute inflammatory, granulomatous, or benign neoplastic lesions.

CASE REPORTS

CASE 1.—The first patient, a 16-year-old Italian girl, came to the Out-Patient Department in August, 1934, complaining of a painful swelling on the right side of the anal region of one month's duration. Examination revealed a dumbbell-shaped, nonfluctuant, moderately tender, firm mass extending transversely across the perineum anterior to the anus (Fig. 1). The overlying skin was slightly reddened and edematous. The right side was slightly the larger. No abnormal lymphadenopathies were found at this time. No ulceration or involvement of the vaginal or rectal mucosa had occurred.

This lesion was thought to be of a low grade inflammatory nature, and ambulatory treatment consisting of hot sitz baths was advised. In spite of this therapy the mass progressively enlarged and failed to soften. Tests with Frei antigens were inconclusive. One month later, biopsy of the perineal mass submitted for

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Case 1

Case 2

Malignant Perineal Tumors

Fig. 1.—Diagrams showing area of involvement.

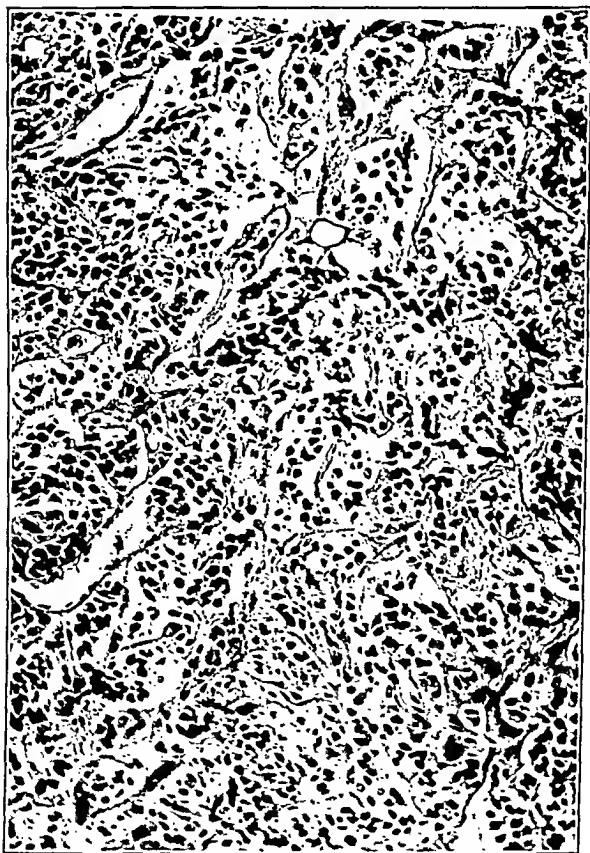


Fig. 2.—Photomicrograph of Case 1. The tumor is composed of small cells which have large hyperchromatic nuclei. It shows indistinct lobulation.

microscopic examination showed small cell carcinoma (Fig. 2) and an excised inguinal node revealed metastasis. Roentgen ray therapy was instituted and the primary tumor disappeared. The patient became progressively worse and widespread metastases occurred (Fig. 3). She died nine months after the onset of symptoms. No autopsy could be obtained.

CASE 2.—The second patient was an 18-year-old colored girl who entered the hospital in October, 1936, complaining of a painful swelling near the rectum of one month's duration (Fig. 1). At its onset it appeared on the left side, was moderately tender, and gradually progressed around behind the anus to the right side. Bowel movements had been painful. Her father had died three years previously of pulmonary tuberculosis.

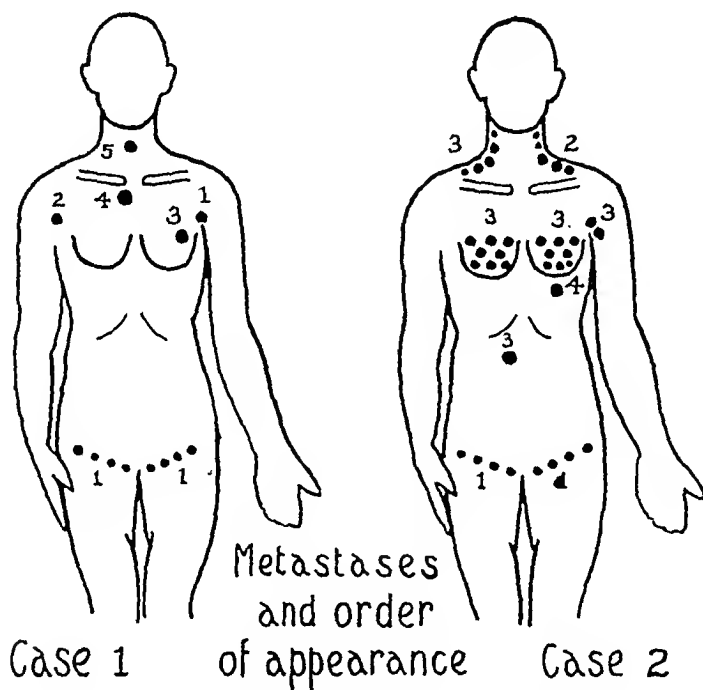


Fig. 3.—Diagrammatic representation of massive gross metastases as observed before death.

The salient features of the examination were: The temperature was normal. The white blood cell count was 10,000. The perineum was warm, tense, indurated, swollen, and edematous. This indurated area encircled the anus posteriorly in the shape of a horse-shoe. The rectovaginal septum was free of induration. No ulceration of the rectal mucosa was found. Small firm inguinal nodes were palpable. Roentgenograms of the spine and chest were normal. Investigation of the genitourinary and gastrointestinal tracts revealed them to be normal. For all purposes this lesion appeared to be inflammatory; however, one of us had had the opportunity of seeing the first patient, and, with that case in mind, a tentative diagnosis of neoplasm was made in this instance. It was thought best that the mass should be incised and if no pus was obtained a biopsy should be procured. No pus was obtained and some tissue was removed for microscopic study. This revealed it to be a small cell carcinoma (Fig. 4). An excised inguinal node showed the same type of tumor.

Radiation therapy was immediately begun by Dr. Eugene Freedman, and the perineal tumor and enlarged inguinal nodes entirely disappeared. Five months later the first apparent metastases were noted, these being in the left supraclavicular space. This was the beginning of a rapid dissemination of the tumor, and metastases were soon apparent in both sides of the neck, both breasts, left axilla, mediastinum, and the skin of the back of the neck and abdominal wall (Fig. 3). The patient had continuous epigastric pain, and bilateral hydrothorax and ascites developed. Respirations became increasingly difficult because of tracheal compression and the increasing pleural fluid. She gradually became comatose and died in



Fig. 4.—Case 2. The tumor is composed of small cells having a scanty amount of cytoplasm and very large pleomorphic nuclei. The tumor in Case 1 presented some areas suggestive of alveolar differentiation.

the sixth month of her illness. Shortly before her death the blood urea nitrogen was 110 mg. per cent and creatinine, 10.8 mg. per cent.

Autopsy was performed by Dr. William Wartman. The external genitals were normal. The anus presented an entirely normal gross appearance, while only rarely were bizarre cells found in the interstices of fibrotic and atrophic muscular tissues in the surrounding regions. The most striking finding was the presence of tumor tissue which had involved in a massive fashion all the perivertebral lymph nodes from the pelvis to the base of the skull. A huge retroperitoneal mass was found

surrounding the ureters and extending into the spleen. The esophagus and trachea were encircled by similar masses. No normal lymphatic tissue was recognizable. A small nodule could be demonstrated in the right ventricle. An interesting finding was the fact that no tumor could be demonstrated in either the lungs or liver.

The similarity of these two interesting cases is at once apparent. Both were in the anal region; both simulated inflammatory lesions; both had widespread metastases; and both were of short duration.

Little is known concerning the cytogenesis of these tumors. The most tenable theory is that they arose from embryologic tissues which were misplaced during the development of the perineum. Most malignant tumors of this region—and they too are uncommon—are mucous-secreting tumors and undoubtedly have their origin embryologically in the remnant of the hind gut. In the past three months we have seen two cases of epidermal carcinoma of this region which did not involve the rectum.

The objective characteristics of inflammation can be explained on a basis of lymphedema resulting from lymphatic blockage, as is often seen in cancer of the breast.

We report these cases with the hope that recognition of other cases will lead to a better understanding of the lesion. We can only assume that the original lesions for which the patients presented themselves represent the primary lesions and this seems justifiable.

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CONGENITAL ANORCHIA, WITH A REPORT OF SIX PROBABLE CASES OF MONORCHIA

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CONGENITAL absence of one or both testicles in man is rare. The medical records of the War Department for the World War report only 52 cases of anorchia in the first two million men examined. Undoubtedly many of these cases and many reports in the literature are confused with arrested migration of the testicle, castration, fusion of the two testes, transverse ectopy, etc.

Cabrol in 1564 reported the first case of congenital bilateral anorchia. From then until 1878, when Gruber reviewed the literature, only 29 verified cases of anorchia had been recorded; of these 7 were bilateral and 22 unilateral; Gruber observed a case of monorchia, which made a total of 23 cases.

Counseller and Walker could find only 9 instances of bilateral anorchia in the available literature up to 1933, and added 2 cases of their own. In 1936 Fleet examined 1 case of unilateral absence of the testis and found that 5 additional cases had been reported since Gruber's series.

Thus, to date, only about 40 cases of anorchia have been recorded; of these 11 were bilateral and 29 unilateral.

St. Hilaire believes that in many cases where absence of one or both testicles has been reported, these organs exist hidden in the abdomen or are atrophic. He doubts if many cases are authentic and states that all reports should give exact details about the arrangement of the other parts of the seminal apparatus. However, embryologically, there is a possibility that a testis like any other organ may be absent, and similar anomalies have been found in the opposite sex and in lower animals. Marehand reports the absence of a left ovary and the greater portion of the tube and broad ligament in a girl, 1 year old. Hobday has found cases of a bilateral anorchid colt and a monorchid horse and states that it is an "occasional" occurrence in animals.

At best, the evidence to prove a case of anorchia is circumstantial, but if after careful anatomic and histologic examination one fails to find a testis, one may conclude that the gonad was congenitally absent, barring operative interference. Detailed and careful search at necropsy should be sufficient to determine the presence or absence of gonads. Such thorough search in persons who are operated upon, of course, is not possible.

During the last eight years at the University of Minnesota Hospitals, 6 cases of probable monorchia have been observed. All the cases were operated upon by O. H. Wangenstein, whose interest and general acquaintance with the subject of the undescended testis are well known. The preoperative diagnosis in these cases was cryptorchidism, but at exploration no testis was found. It is possible that the testis lay hidden elsewhere in the body and was not accessible at operation, but, apart from a gonad in a remotely aberrant position, the absence of the testis is likely. Because of the rarity of this condition at operation and its possible relationship to other anomalies, the following cases are reported:

CASE REPORTS

CASE 1.—L. H., hospital number 54368, aged 8 years, was admitted to the University of Minnesota Hospitals June 4, 1930, and discharged June 17, 1930. He was admitted with the diagnosis of bilateral undescended testis since birth. He also had a slight convergent strabismus.

Physical examination was essentially negative. The left testicle could not be palpated, but the right testicle could be felt in the inguinal canal. It was freely movable, but could not be brought into the scrotum. Examination of the blood and urine was essentially negative.

On June 5, 1930, the patient was operated upon. On the left side, after opening the external oblique aponeurosis, the gubernaculum was seen to come down posterior to the parietal peritoneum and to imbed itself deep to the Poupart ligament. There was no definite evidence of testis. A small hernial sac was felt. This was dissected free from the gubernaculum and ligated. A small band was found to run behind the bladder in the usual course of the vas deferens. This could not be identified as vas. No internal spermatic artery was found. Exploration of the retroperitoneal space and peritoneal cavity with the finger revealed no testis. Immediately overlying the left femoral artery was a small hard mass which appeared to be a lymph node. This and the gubernaculum and associated structures were removed. Microscopic sections of the tissues removed (Hospital operation 30-954-5-6-7-8) showed several lymph nodes, gubernaculum, and vas deferens. A hernioplasty was performed on both sides and an orchiopexy on the right.

CASE 2.—W. O., hospital number 642893, aged 16 years, was admitted to the University of Minnesota Hospitals Oct. 15, 1935, and discharged Nov. 11, 1935. Since birth he had had undescended testes. He had never noticed the testes in the scrotum or felt them in the canals. His home doctor had injected the left inguinal canal for hernia.

Physical examination revealed the penis and scrotum to be somewhat underdeveloped. The testicles were not felt in the scrotum or in the inguinal region. The patient had a congenital heart lesion, probably on the basis of pulmonary stenosis. His general appearance was that of a cretin. A prostatic smear was negative for spermatozoa. Basal metabolic rate was 46 per cent.

On Oct. 18, 1935, the patient was explored through a right oblique inguinal incision. No testis was found. Dissection was made far into the retroperitoneal region as far as the bifurcation of the aorta. The peritoneal cavity was opened also, but no trace of testis, vas deferens, or gubernaculum was found. A hernioplasty was performed and the wound closed. On Nov. 1, 1935, an orchiopexy was performed on the left side.

CASE 3.—A. B., hospital number 639502, aged 24 years, was admitted June 13, 1935, and discharged June 26, 1935. The patient said the left testicle had never been felt. The right testicle had always been normal in size and position. No hernia could be demonstrated on physical examination nor could the left testicle be palpated.

On June 14, 1935, through a left inguinal incision, the patient was explored. There was a spermatic cord in which the vas deferens and vessels were found. No testis was found. The retroperitoneal space was explored. Failing to find testicular tissue, the vas deferens was amputated near the bladder and the spermatic cord cut high in the retroperitoneal region. A small hernial sac was found which was ligated. A Bassini hernioplasty was done in the usual fashion.

CASE 4.—G. S., hospital number 55234, aged 8 years, was admitted Aug. 12, 1930, and discharged Aug. 23, 1930. For two years prior to the admission, it had been noted that the left testis of the patient was not in the scrotum. At no time had it caused him any discomfort.

Physical examination was essentially negative except that no left testicle could be felt. The right testis was normal in size, shape, and position. The external genitals were normal.

On Aug. 13, 1930, an operation was performed. On dividing the external oblique aponeurosis, the terminal end of the spermatic cord was seen to insert into the outer leaf of the external oblique aponeurosis. It did not extend into the scrotum. With the slightest traction, it was detached. Upon following this medially the vas and spermatic vessels were seen, both of which were extremely small. What seemed to be testis and epididymis were mere nubbins of tissue, about $\frac{1}{8}$ or $\frac{1}{16}$ the size of the other testis. This tissue was removed, but on cut section proved to be scar tissue. No testis was found. An indirect inguinal hernia was repaired.

Microscopic study of the removed tissue (Hospital operation 30-1399) showed no evidence of testicular tissue. There were epididymis, spermatic cord, spermatic blood vessels, muscle and fibrous connective tissue (gubernaculum?) present.

CASE 5.—R. U., hospital number 640161, aged 11 years, was admitted July 24, 1935, and discharged Aug. 7, 1935. The patient had a right inguinal hernia and bilateral undescended testis. One year before he had had a right herniorrhaphy elsewhere, at which time no right testis was found.

On July 25, 1935, the patient was operated upon and a recurrent right indirect inguinal hernia was repaired. A normal spermatic cord was found, but no definite testis was isolated. In the retroperitoneal space there was a small piece of tissue that was thought to be testis as there was a small vascular pedicle running from it toward the renal region. This tissue and the spermatic cord in the inguinal region were removed for histologic study. A hernioplasty according to Andrews' technique was performed.

Microscopic sections of the removed tissue (Hospital operation 35-2080 and 2079) showed fibrous tissue, blood vessels, and a small lymph node.

CASE 6.—W. R., hospital number 664234, aged 20 years, was admitted March 16, 1938, and discharged March 28, 1938.

The patient had presented bilateral undescended testis since birth. A year before his home doctor had tried anterior pituitary-like substance (antuitrin-S) with no results.

The right testis could be felt overlying the external oblique aponeurosis, having migrated out to the external abdominal ring. There was an indirect inguinal hernia present. A testis could not be felt nor a hernia on the left side.

A right orchiopexy and hernioplasty was performed Dec. 3, 1937.

The patient returned March 17, 1938, at which time the scrotal-crural anastomosis on the right was undone and exploration carried out through a left oblique inguinal incision. The conjoined tendon was intimately attached to the external oblique aponeurosis at Poupart's ligament. There apparently was no vas deferens. A tiny remnant of a structure coming from the bladder on the outside of the peritoneum may have represented vas deferens. The gubernaculum extended into the scrotum. There was no testis or spermatic vessels that could be found.

A hernioplasty was performed.

Microscopic sections of the tissues removed (Hospital operation 38-802-3-5-6) revealed probable vas deferens, fibrous tissue, and blood vessels; no testis.

DISCUSSION

1. *Etiology*.—Congenital absence of the testis is said to be due to prenatal atrophy resulting from intranterine disease or trauma, or to partial or total failure of embryonic development of the sex glands. Counseller and Walker, however, do not believe that any disease process, either before or after birth, could occur which would not leave some remnant of tissue that could be identified. Furthermore, the association of this anomaly with absence of the kidney and ureter, extrophy of the bladder, imperforate anus, urethrorectal and vesicorectal fistulas (Collins, Boyden, Walker and Guinard) strengthens the belief that anorchia is a developmental defect.

2. *Varieties of Anorchia*.—This anomaly may exist in various degrees. Sebileau and Descomps claim that there is no report in the literature of complete absence of the deferent canal, but Velpeau and Blandin have reported complete unilateral absence of the testicle and seminiferous pathways (Thorek). Gruber reported 5 instances where the testis, epididymis, and part of the vas deferens were missing and 5 other cases where the testis was absent but the epididymis and ductus deferens present. A summary of his findings in our cases is tabulated in Table I.

It is interesting that unilateral anorchia is more common on the left side. The incidence of left- to right-sided absence of the testis is 2:1 according to Sebileau and Descomps and 4:1 according to Godard. In our series the deformity was four times on the left and twice on the right.

3. *Relation of Anorchia to*

A. *Development of the Secondary Sex Characters*: A bilateral anorchid is a true natural eunuch with feminine aspect and development (Thorek). On the other hand, the external genitals and secondary sex characters of a monorchid may develop normally. It may be difficult to distinguish among a monorchid in which the one testis is abdominally retained, a cryptorchid with abdominal gonads, and a bilateral anorchid. In fact, up to puberty it is impossible to differentiate these entities.

TABLE I
SUMMARY OF THE FINDINGS IN SIX PROBABLE CASES OF MONORCHIA

| SUMMARY OF THE FINDINGS IN SIX PROBABLE CASES OF MONORCHIA | | | | | | | | | | |
|--|--------|--------|---|-----------|--------|-------------|--------------|-------------------|----------|---------------------|
| NAME | NUMBER | AGE | DIAGNOSIS | MONORCHIA | | | | | | |
| | | | | SIDE | TESTIS | EPIDIDYIMIS | VAS DEFERENS | SPERMATIC VESSELS | PROSTATE | HERNIA AT OPERATION |
| G. S. | 55234 | 8 yr. | Left undescended testis | Left | Absent | + | + | + | Normal | + |
| L. H. | 54368 | 8 yr. | Bilateral undescended testes | Left | Absent | Absent | + | + | Normal | + |
| W. O. | 642893 | 16 yr. | Bilateral cryptorchidism; congenital heart disease (pulmonary stenosis); left inguinal hernia | Right | Absent | Absent | Absent | Absent | Normal | Absent |
| R. U. | 640161 | 11 yr. | Bilateral undescended testes; inguinal hernia | Right | Absent | Absent | + | + | Normal | + |
| A. B. | 639502 | 24 yr. | Left undescended testis | Left | Absent | Absent | + | + | Normal | + |
| W. R. | 664234 | 20 yr. | Bilateral undescended testes; inguinal hernia | Left | Absent | Absent | + | ? | Normal | + |
| | | | | Left | Absent | Absent | + | ? | Normal | + |

After puberty, it still may be impossible to distinguish between a cryptorchid with abdominal gonads and a monorchid with an abdominal testis. Both may develop normal secondary sex characters. However, distinction may be made between these conditions and complete anorchia, not only by the lack of secondary sex characters in the latter, but also by the status of the genital function (Godard). A man congenitally deprived of both testes is impotent; he is able to have rare erections, but he does not ejaculate semen. He differs from the double cryptorchid or monorchid in that such patients, if they have one functioning testis, are potent and may be able to reproduce.

Of the three cases past puberty in this series, two were normal as to secondary sex characters. The third patient (W. O.), aged 16 years, had the appearance of a eunuch; the penis and scrotum were underdeveloped.

B. Hernia: As mentioned above, it is impossible to differentiate by inspection alone between the congenital absence of testes and cryptorchidism; in fact, most anorchids are thought to be cryptorchids before operation. Some authors have stressed the presence or absence of hernia in the differential diagnosis of these two conditions. It is known that all cryptorchids have a potential, if not an actual, hernia. Eeles found that more than one-half of the cases of retained testes actually have an associated hernia. Counseller and Walker found in their series that, when definitely stated, a hernia was not present in 5 anorchids. They believe that if a hernia is absent and the testes not palpable, while the testes are probably only undescended, they may be completely absent.

While this may be a valuable sign, it should be emphasized that 3 of 6 of our cases had an associated inguinal hernia which was diagnosed before operation, and at operation all 6 cases had evidence of a hernia. Similarly Dass and Berry have reported the absence of the testes with hernia. Thus, while absence of a hernia and failure to palpate the testes may suggest anorchia, it should be remembered that anorchia may be present with a coexisting hernia.

C. Pseudohermaphroditism: If the patient has a perineal hypospadias, undescended testes, and anomalies of the secondary sex characters, the possibility of pseudohermaphroditism should be considered. While hermaphroditism and pseudohermaphroditism are rare, they are more common than anorchia, and the similarity of the anomalies may obscure the true diagnosis. Urethroscopy may be of diagnostic value in these cases, for what was thought to be a normal urethra may actually be a persistent urogenital sinus into which a hypoplastic vagina opens. One of the cases (W. R.) was examined with an urethroscope by C. D. Creevy after operation to rule out this possibility; no other anomaly was found.

D. Cryptorchidism: At the University of Minnesota Hospitals, 143 cases of undescended testes have been seen. To date, 6 cases of probable monorchia have been operated upon (4.2 per cent). Whether there is some relationship between anorchia and cryptorchidism is speculative.

It is generally known that there are degrees of separation of the epididymis from the testes in cryptorchidism. Conneller and Walker suggest that cases of anorchia may represent a final degree of separation with resulting atrophy and disappearance of the testis.

Hunter believed the undescended testis to be congenitally imperfect. If this be true, one would expect to find a gradation in cryptorchidism from absence of the testis to almost perfection. Other writers, such as Moore and Wangenstein, while accepting that some retained testes are imperfect *ab initio*, believe that most of the imperfection becomes manifest at puberty as the result of temperature, hormonal and pressure influence. Certainly it is impossible to distinguish grossly or microscopically between a descended and undescended testis up to puberty. Moreover, most of the ectopic testes seen shortly after puberty show the upper degrees of development and only with time do atrophic changes appear.

For these reasons, it is believed that the incidence of anorchia to cryptorchidism in this series (4.2 per cent) is probably coincidental and not of significance. The final word as to a possible relationship cannot be said, however, until the cause of these two conditions is known.

SUMMARY

Congenital anorchia is a rare anomaly. To date about 29 unilateral and 11 bilateral cases have been reported in the available literature.

Six cases of probable monorchia are presented in this paper. Four of these occurred on the left side and 2 on the right. Three cases had an associated inguinal hernia, which was diagnosed before operation, and at operation all 6 cases had evidence of hernia. The possible relationship of anorchia to other anomalies, such as cryptorchidism, hermaphroditism, etc., has been discussed.

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TORSION OF THE UTERINE ADNEXA

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TORSION of the uterine adnexa must be classed among the rarer gynecologic crises. Although a number of observers have described the clinical symptoms and operative findings, the standard textbooks allot the condition scant mention, with the result that, comparatively unknown to the majority, it goes unrecognized and an accurate pre-operative diagnosis is seldom made. The surgeon confronted with a twisted gangrenous tube is often unable to discuss his case intelligently until he has consulted his library.

While torsion of the pedicle of ovarian cysts is relatively common, torsion of the Fallopian tubes, with or without torsion of the ovaries, is encountered more rarely. In the three cases which the writer is reporting, Case 1 showed bilateral tubal torsion, both ovaries being normal; in Case 2 there was torsion of the right tube only, the other adnexa revealing no pathology; and in Case 3 both the right tube and the right ovary were involved in the torsion, while the left tube was adherent from the isthmus to the fimbriae to a large multilocular cyst of the left ovary.

The etiology of torsion of the adnexa has never been adequately explained. Anspaeh believes the exciting causes of torsion of the tube are the same as those producing torsion of the pedicle of ovarian cysts and quotes Storer: "disturbance of the equilibrium of the tumor by irregular growth, changes in abdominal pressure during pregnancy, and immediately following labor, distention and evacuation of the bladder, difference in pressure during the act of emptying the bladder, peristalsis, sudden movements of the body, and trauma, including gynecological examinations." Other writers, attempting to prove that torsion can occur in perfectly normal adnexa, list trauma and peristalsis as the most plausible causative factors, and in support of their theory call attention to the more frequent occurrence of right-sided torsion. They reason that the muscles of the right side of the body are used more often than those of the left for heavy lifting, etc., and that the anatomic arrangement of the organs on the right side gives more leeway for peristalsis to produce torsion than is possible on the left where the sigmoid wedges the contents of the left pelvis in place. Shute believes the foundation is laid in fetal life when the tube is considerably longer than the overlying peritoneum and therefore assumes convolutions and spirals, and that this discrepancy persists to about puberty and is common even in adults. In explanation of adnexal torsion both

Shute and Anspach refer to the studies of Payr and Sellheim. Briefly stated the theory is as follows: The artery or arteries in the pedicle of an organ are shorter, thicker, and obviously less distensible than the veins in which the circulation is tortuous. Payr found that by injecting under uniform pressure the pedicle of a spleen resting on water (injecting the artery and veins simultaneously), he was able to produce rotation of the organ in an arc of 125 degrees. Although the writer has not encountered this particular deduction, Payr's theory might explain not only the rare phenomenon of torsion of the omentum, but also volvulus and intussusception. The circulatory disturbance combined with peristalsis might act as the causative factor.

In order to gauge the possibility of torsion in the normal adnexa, it might be well to review their anatomy. The normal tube is approximately 12 cm. in length. There are four subdivisions: the short uterine portion, the slender isthmus, the ampulla, which is the dilated outer two-thirds, and the fimbriated funnel-shaped infundibulum. The muscular wall grows progressively thinner from the isthmus outward. There are three coats: the serous, underlying which are found the blood vessels and nerves; the muscular, the outer layer of which is longitudinal and the inner layer circular; and the mucosa. Although the outer two-thirds of the tube appear much thicker, this is simply due to the arborescent corrugations of the mucosa. The outer two-thirds of the tube are obviously heavier and tend to fall downward and inward on the posterior surface of the broad ligament. Frequently, one of the fimbriae is attached to the outer pole of the ovary. The writer has made gentle efforts to produce torsion in the normal tube by grasping the ampulla with forceps and twisting it both clockwise and counter-clockwise. The tube is returned promptly to its former position. The ovaries are held in place by the meso-ovarium, a double layer of peritoneum springing from the posterior surface of the broad ligament. Between the laminae run the blood vessels and nerves to enter the hilum of the gland. There are, besides two other supporting structures, first, the ovarian ligament, consisting of smooth muscle, lying between the layers of the broad ligament and extending from the uterine extremity of the ovary to the lateral aspect of the uterus where it is attached between the origin of the tube and the origin of the broad ligament; second, the ligament commonly known as the infundibulopelvic ligament, which extends from the tubal or outer extremity of the ovary to the lateral wall of the pelvis and is the lateral fifth of the broad ligament unoccupied by the tube. It is attached, after crossing the external iliac vessels, to the fascia and peritoneum covering the psoas major muscle. This ligament carries the ovarian vessels and nerves.

It is a moot question whether the normal tube is ever the site of torsion. In the three cases observed by the writer, the increase in weight of the distal portion of the tube was due either to a collection of fluid,

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operative diagnosis of torsion of the tubes only to find at operation cystic ovaries adherent to the posterior surface of the broad ligament, which were causing intermittent attacks of agonizing pelvic pain. In several other instances I believe slight torsions occurred which righted themselves after rest in bed or at the termination of pregnancy.

The symptoms of adnexal torsion are easily confused with those of appendicitis, and this may be one explanation for the greater number of right-sided torsions found at operation. There is a tendency toward conservative treatment in left-sided abdominal pain. The symptoms also may be ascribed to ectopic pregnancy. The attacks of pain are sudden in onset and intermittent at intervals of days, months, or years. Constipation, nausea, and vomiting usually are concomitant. There is, as a rule, a rise in temperature and leucocytosis. While many writers believe that a history of trauma can be elicited, others cite examples of the pain coming on in the middle of the night's slumber or during a prolonged hospital stay in bed. There is also the same difference of opinion as to relation to the menses. The following characteristics were common to the three cases observed by the writer:

1. Sudden onset of abdominal pain, paroxysmal and severe, which soon became localized laterally in the pelvis.
2. Nausea and vomiting from twelve to twenty-four hours after initial symptoms.
3. Absence of constipation.
4. No apparent relation to menses, since one case occurred two weeks after the last period; one, nine days; and the third, six months after menstruation had ceased.
5. None gave a history of trauma or of unusual exertion.
6. Examination in each case showed a tender mass of indefinite outline and doughy consistency, lateral to the uterus.
7. All gave histories of prior attacks of pain, similar in location but of less intensity.

On the other hand, two showed leucocytosis (18,000 and 20,000) with a neutrophile count of 88 per cent and 92 per cent. The third had a count of 8,000 with 68 per cent neutrophiles. Temperatures upon admission to the hospital were respectively 101°, 101.5°, and 97.5°; pulse rates, 118, 100, and 60. Two developed dark, bloody, foul discharge some hours after the onset of pain, while one had no discharge whatever. In all three cases the affected tubes were found gangrenous at operation.

CASE REPORTS

CASE 1. - Mrs. C., aged 32 years, two induced abortions, no full-term children. Last abortion occurred three years before she was seen by me and was followed by a few days of fever which did not rise above 100°. One year after this, she complained of acute pain in the right ovarian region. The appendix had been removed

or in one case to the presence of an ovarian cyst with elongated ligaments, and the enormously thickened and congested meso-ovarium was highly suggestive of the vascular origin of the torsion. There was nothing in the appearance of the tubes suggestive of either a congenital deficiency of the peritoneal coat or of the presence of the fetal spiral type except, of course, the twists. As Anspach remarks: "The normal Fallopian tube is of such size and structure that strangulation by torsion is almost inconceivable. When, however, the outer part of the tube becomes enlarged or heavy, and is not adherent to the surrounding parts, the mechanical conditions favoring torsion may be said to exist, viz., a freely movable tumor (the enlarged ampulla of the tube), attached to a more or less fixed base (the uterus) by a pedicle (the isthmus of the tube and the mesosalpinx). Under such circumstances the same forces which cause torsion of ovarian or parovarian tumors may come into play with a similar result." On the other hand, Shute holds that inflammation is a debatable etiologic factor; that a pliable normal tube should twist more easily than a thickened inflamed one. It is impossible to arrive at a definite conclusion, and the solution is just about as deducible as whether the egg or the chicken came first in the scheme of existence. Even histologic examination of an operative specimen offers no proof for the changes in the tube tend to obscure the picture for the pathologist. When a gangrenous tube is sent to the laboratory, it is very difficult to distinguish whether it was diseased before the torsion took place, or if the pathology has been produced by the torsion. In the cases reported of pyosalpinx and hydrosalpinx with closure of the ostia, the causative pathology is more apparent. Hematosalpinx, however, might be the result and not the cause of torsion.

Torsion of the adnexa is probably a more common occurrence than the rarity of its recognition would indicate. It is possible for the adnexa to become twisted and to right themselves without intervention. In a number of instances there is even distinct evidence that self-amputation of the tube has taken place with subsequent absorption. In one case, autopsy on an aged woman disclosed the calcified remains of what appeared to be an ovary adherent to the pelvic wall. So far the writer has been unable to find any record of a fatal case. The abdominal cavity may just as well be able to care for a self-amputated tube as it does for the placenta after cesarean section for abdominal pregnancy. It follows, therefore, that nature might deal adequately with the majority of these cases without operative interference. Certainly, our surgical training inclines us to remove at once any gangrenous intra-abdominal organ. In the past there must have been many cases where spontaneous recovery resulted. But since torsion has occurred in tuberculous or otherwise infected tubes, and we cannot be certain of the pathology until laparotomy is performed, expectant treatment is strongly disapproved. On two occasions I have made a pre-

hours, a dark, bloody discharge appeared which she believed to be a menstrual flow. On the third day of the attack, she had nausea and vomiting. The pain gradually became worse, the paroxysms lasting from fifteen to twenty minutes, but being comparatively infrequent, as, at times, two or three hours were spent in comfort. The temperature was 97.5° ; pulse, 60; total white count, 8,000; neutrophils, 67 per cent; blood pressure, 126 systolic and 80 diastolic. General examination, aside from the usual picture of undernutrition, was essentially negative. There was no distention of the abdomen and no rigidity. There was no tenderness at McBurney's point. Pressure over Poupart's ligament on the right side produced pain. Vaginal examination showed an anteflexed uterus studded with fibroids. On the left side a tense mass, occupying the entire space between the uterus and the wall of the pelvis, was felt. On the right side a soft doughy mass, exquisitely tender, could be palpated next to the uterus. Slightly lateral to it, the ovarian cyst, discovered at the previous



Fig. 1.—The left ovary shows a multilocular cyst, no torsion. The right ovary shows the mottling described in the pathologic report. Tortuous tube and elongated and thickened ovarian ligament.

examination, could be made out. I was struck by the absence of any signs of shock. She was sent to the hospital for observation and operation was performed the next morning.

Operation.—Midline incision was extended from the symphysis upward to a point just below the umbilicus, sweeping to the left of the umbilicus and carried down to the rectus sheath, about one inch above it. The rectus sheath was divided and the left and right recti retracted. The peritoneum was opened in the midline. Inspection of the pelvis showed a uterus studded with fibroids. Immediately behind the left broad ligament was a large multilocular ovarian cyst (Fig. 1) with the left tube adherent from the isthmus to the fundus. Tube and cyst were removed en masse. The right adnexae were not at first visible. Palpation of the cul-de-sac showed the right ovary and right tube gangrenous as a result of torsion. The tube showed four clockwise twists and was completely devitalized to the cornu. It was clamped at its junction with the uterus, and tube and ovary were removed en masse.

several years previously. She was seen by a physician who told her that the ovary and tube had become twisted and that she would probably be all right with a few days' rest in bed. On the second day the pain abated, and on the third day she was able to resume her usual activities. A year later she had a similar attack, but called no physician, the pain subsiding after four or five hours. When seen by me, she was in a condition of mild shock. The lower abdomen was rigid; temperature was 100°. There was a slight dark bloody discharge. The menstrual period had occurred two weeks before. Blood count, 18,000 leucocytes, with 88 per cent neutrophils. Vaginal examination showed intense tenderness and a doughy mass on each side of the uterus. She was taken to the hospital at once. The abdomen was opened in midline and both tubes found twisted one and one-half times and purplish black. The right tube was twisted in a clockwise direction; the left tube counterclockwise. The distal thirds of both tubes were distended with clear fluid. A bilateral salpingectomy was performed. No adhesions were noted in the region of the cecum. There was no serum or blood in the peritoneal cavity. The ovaries were normal and were not disturbed. This attack occurred on the fourteenth day after the first day of menstruation.

CASE 2.—Mrs. G., aged 26 years, para i, normal pregnancy three years before. No history of fever during the puerperium. No history of menstrual disturbance. Patient was brought to Mercy Hospital, New Orleans, suffering with intense pain on the right side. The appendix had been removed five years prior to admission. She related that she had had two attacks of lesser intensity but with pain of the same character; the first, six months before admission; and the second, one year before. Blood count, 20,000 white cells, with a differential of 92 per cent neutrophils.

The abdomen was opened in midline. The right tube was twisted clockwise two and one-half times and was bluish black in color. It was removed. The right ovary and left adnexa were normal. There were no adhesions at the site of the appendectomy. Examination of the tube showed the ostium closed and the ampulla distended with clear fluid. Recovery of patient was uneventful.

CASE 3.—Mrs. M., aged 42 years, normal weight 167 pounds, present weight 117 pounds; two children, aged 22 and 19 years. Periods started at eleven years, were regular, and lasted from eight to ten days. Both deliveries were normal. One induced abortion after four months' gestation eleven years ago; short, but febrile, convalescence. Tertian malaria ten years ago. Six years ago she began to have pain in the right chest, followed by five days of fever ranging from 99° to 101°. This pain was thought to be pleurisy; a year later pain developed over the right hip. Examination revealed a small right ovarian tumor. The periods since then have been three to four months apart and very profuse, lasting from ten to twelve days. For three years she has had almost daily pain lasting from five to thirty minutes. The last period occurred six months before admission to the hospital. She believed she was changing life prematurely. Three months ago she had paroxysmal pelvic pain that lasted several days.

Examination in 1932 showed an anteverted uterus containing numerous small fibroids. On the right side of the abdomen there was a mass which was thought to be a small ovarian cyst. The left side was practically normal. She was advised at the time, on account of the frequency of the pain, to have an operation. I was of the opinion that the pedicle of the cyst had become twisted from time to time. I next saw her professionally in September, 1935. She had been feeling ill for five days but had been confined to bed for twenty-four hours only. The attack was ushered in by paroxysmal pains in the right lower quadrant. After twenty-four

tached to the tube in the region of the ampulla is found a thin-walled cyst, containing clear straw-colored fluid, and measuring 1 cm. in diameter.

The right ovary (Fig. 2) measures $6\frac{1}{2}$ to 7 cm. in width, 7 cm. in length and 3 cm. in thickness. Its outer surface is covered by smooth, glistening membrane which is mottled in color, there being the deep red, purplish color of a hemorrhagic cyst, the small light pink striations of congested blood vessels, patches of extravasated blood into the tissues of the ovary. The light gray to yellow color is that of the follicular cysts. The ovary is found attached to the tube by a pedicle which measures 3 cm. in length and 4 cm. in width. It is covered by smooth, glistening peritoneum and shows quite a bit of congestion of its tissues.

The tube attached measures 12 cm. in length and varies in width from 3 mm. at the isthmus to 6 mm. at the ampulla. The fimbriated end is found patent and is of a light pink color. The remainder of the tube is gangrenous. The broad ligament measures 3 cm. in width, $\frac{1}{2}$ cm. in thickness.

The appendix measures 5 cm. in length and $\frac{1}{2}$ cm. in width. Its outer surface is covered by a smooth, glistening membrane, light pink in color. The blood vessels show some slight degree of congestion. Palpation reveals a firm consistency, the appendix having the feel of a fibrous cord. Incision through the appendix shows the lumen to be patent, containing a small amount of mucus and feces. The mucosa is smooth and glistening, light pink in color, with an occasional hemorrhagic spot.

Microscopic Diagnosis.—Hyperplasia of the endometrium, slight fibrosis of the wall of the uterus, multiple leiomyomas of the wall of the uterus, multiple follicular cysts of the right and left ovaries, with congestion of the blood vessels and extravasation of blood into the tissues surrounding the blood vessels and cysts; left salpinx normal except for moderate congestion. The blood vessels and supporting tissues of the right ovary show congestion. Chronic inflammatory appendicitis.

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A supravaginal hysterectomy was then done. No free fluid was found in the pelvic cavity. The appendix was grossly normal; it was removed. The stumps of the infundibulopelvic and round ligaments were sutured to the cervix. The abdominal wall was closed in layers without drainage.

Laboratory report.—The specimen received consisted of uterus, right and left tubes, with large cystic ovaries attached, and an appendix.

The uterus is irregular in shape, having several nodular growths, varying in size, located within its wall; it measures 6 by 6 by 7 cm. The outer surface is partially covered by smooth, glistening peritoneum with a few lacerations over the fundus, evidently due to the application of instruments at time of operation. The remainder of the surface is rough and irregular showing fibrous tags and several blood vessels. On the posterior surface near the isthmus there is found a subserous leiomyoma, measuring 2 cm. in diameter. The color of the uterus is normal pink. Palpation reveals a varying consistency and several nodules located in the muscular coat which are firm, while the remainder of the musculature is more or less flabby. Incision through the uterus shows the wall to vary in width from $1\frac{1}{4}$ cm. at the isthmus to

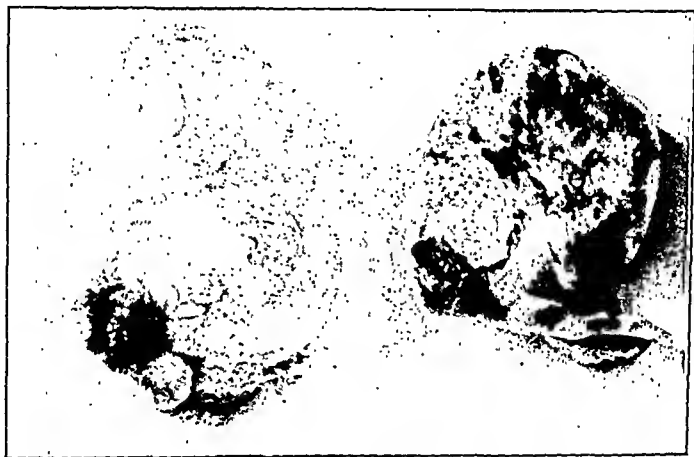


Fig. 2.—Another view of both ovaries. The white area at the attachment of the ovarian ligament to the ovary was entirely bloodless.

$2\frac{1}{2}$ cm. at the fundus. The lumen is outlined by smooth, glistening endometrium which measures about 2 mm. in thickness. Its surface shows small petechial clots near the fundus and covering the leiomyoma lying in this region. There are several leiomyomas in the wall of the uterus that vary in diameter from 1 cm. to $2\frac{1}{2}$ cm. and which are located throughout the wall of the uterus, some being submucosal and others subserous.

The left ovary (Fig. 2) is made up of three large cystic cavities. The largest of the two measures 3 cm. in diameter; the smaller one, $2\frac{1}{2}$ cm. in diameter. Scattered over the surface are a few small cysts which vary from $\frac{1}{2}$ to 1 cm. in diameter. The outer surface is covered by smooth, glistening peritoneum, bright pink to gray in color. Palpation reveals a fluctuant consistency. An incision through the ovary shows it to be made up completely of cystic cavities, there being no normal ovarian tissue remaining. The contents of the cysts are fluid of a straw color. The lining of the cysts is smooth, glistening, and shows no irregularities.

The salpinx attached to the ovary measures 9 cm. in length and varies in width from 4 mm. at the fimbriated end to 6 mm. at the ampulla. The fimbriated end is found patent. The outer surface is smooth, glistening, and pink in color. At-

THE TOXICITY OF BILE SALTS

In order to determine the relative toxicity of the sodium taurocholate and sodium glycocholate, we injected intramuscularly varying quantities of the commercial salts in sterile solution into guinea pigs weighing between 498 and 512 gm.

TABLE I

| GUINEA PIG | WEIGHT IN GM. | SODIUM TAUROCHOLATE MG. | SODIUM GLYCHOLATE MG. | REMARKS |
|---------------|------------------|-------------------------------|-----------------------------|-------------------------|
| 19 | 510 | 200 | | Living and well, 8 days |
| 20 | 500 | 300 | | Killed, 4 days |
| 21 | 506 | 500 | | Died, 3-4 days |
| 22 | 498 | 700 | | Died, 1 day |
| 23 | 511 | 500 | | Died, 3 days |
| 24 | 508 | 500 | | Died, 3 days |
| 25 | 510 | | 500 | Died, 4 days |
| 26 | 512 | | 500 | Died, 3 days |
| 19* | 508 | | 300 | Living and well |

*Used for second time eight days after first experiment.

It is thus seen that the toxicity of the bile salts is roughly quantitative in its action, and that in this series there was little difference to be seen in the relative toxicity of the two bile salts used.

Throughout this experimental work, lethal doses of bile were calculated on the basis of its bile salt content; this was determined by the method of Gregory and Pascoe⁴ which is based upon the color produced by the interaction of bile salts with furfural in a sulfuric acid solution, heated. This color is compared in a colorimeter with a standard concentration of bile salt solution similarly and simultaneously treated. The color is due to the cholic acid portion of the conjugated bile acids. We found the cattle bile, which was mainly used in our experiments, to contain from 95 to 170 mg. of bile salts per cubic centimeter; dog bile, about 200 to 250 mg. per cubic centimeter; human gallbladder bile, about 46 mg. per cubic centimeter.

THE BACTERIAL FACTOR

Into nine dogs, cattle bile or human bile was injected intraperitoneally.

In the four dogs that died, the peritoneal fluid was cultured in brain broth, and in every case gas was present in the culture and large gram-positive rods with truncated ends were present either in pure or in mixed culture.

In two dogs pure cultures of *Clostridium welchii* were injected into the peritoneal cavity with no untoward results: (1) Dog 12 A, 18.2 kg., 30 c.c. Welch culture injected intraperitoneally; well six weeks; (2) Dog 17, 6.8 kg., 10 c.c. Welch culture injected intraperitoneally; well six weeks.

THE CAUSE OF DEATH IN BILE PERITONITIS

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ALTHOUGH bile peritonitis is relatively uncommon, the mortality rate is excessively high, usually given around 50 per cent; it has been shown that it accounts for a significant number of deaths following operations upon the biliary tract. As soon as the importance of this hitherto rarely recognized condition was demonstrated, numerous experimental attempts were made to ascertain the mechanism of death in bile peritonitis.

It is quite obvious that infected bile inundating the peritoneal cavity might engender a suppurative or pyogenic peritonitis, the same as perforation of an infected appendix; the malignant character of this type of bile peritonitis is conceded by most authors, consequently the efforts of most investigators have been applied to determine the effects of sterile bile in the peritoneal cavity.

The opinions are controversial and may be placed into two categories:

A. Sterile bile in the peritoneal cavity is innocuous. Noetzel,¹⁵ McWilliams,¹³ Orth,¹⁶ Sieh and Fraenkel,²¹ Buchanan,³ Ritter,¹⁹ Fraenkel and Krause,⁵ and many others.

B. Sterile bile in contact with the peritoneal surfaces is harmful. In the latter group there are again divided opinions which may be classified as follows: (1) Death in choleperitonium is due to the toxicity of one or more components of bile, especially the bile salts. Wangenstein,²³ Horrall,^{10, 11} Horrall and Carlson,¹² Brand,² Rywosch.²⁰ (2) Death is due to endogenous infection; that is, the bacterial factor, especially *Clostridium welchii*. Rewbridge and Hrdina,^{17, 18} Andrews, Rewbridge, and Hrdina,¹ Dvorak.⁴ (3) Shock from fluid loss is the chief lethal factor. Harkins, Harmon, Hudson, and Andrews,^{7, 9} Trusler and Martin,²² Moon and Morgan.¹⁴

In order to demonstrate the noxiousness of intraperitoneal sterile bile and, more specifically, to determine the cause of death in choleperitonium, several series of animals were subjected to procedures designed to imitate as closely as possible the circumstances under which the condition occurs clinically. This, of course, is only crudely accomplished and only by inference can the theories thus obtained from such experiments be applied to patients.

fluid were found. This fluid was cultured in each case. A large rod similar to *Clostridium welchii* was found in

them that, if death were due to a *Clostridium welchii* toxemia, the outcome might be deferred or avoided by the administration of doses of antitoxin. Accordingly, in nine dogs the common bile was drained and the gall bladder defundated and antitoxin was injected into the peritoneal cavity. One dog was accidentally strangled and lived twenty-nine days, was sacrificed, and a walled-off abscess containing bile-stained pus was found in the right upper quadrant. The other dogs died from thirty-six to forty-eight hours after operation. All anaerobic cultures (brain broth) from the peritoneal cavity were positive for a gram-positive bacillus resembling *C. welchii*.

TABLE IV

| AMOUNT ANTITOXIN, BRAND | BILE CUL- TURE | MUSCLE CUL- TURE | LIVER CUL- TURE | DEATH | PERITO- NEAL FLUID | CULTURE PERITO- NEAL FLUID |
|----------------------------|----------------------|------------------------|-----------------------|---------|--------------------------|-------------------------------------|
| E. Lilly (Welch) | + | - | + | Strang. | | |
| E. Lilly (Welch) | + | + | - | 29 days | | |
| E. Lilly (Welch) | + | + | + | 2 days | 600 c.c. | + |
| E. Lilly (Welch) | - | + | + | 2 days | 200 c.c. | + |
| E. Lilly (Welch) | - | - | - | 2 days | 500 c.c. | + |
| E. Lilly (Welch) | - | + | + | 36 hr. | | |
| E. Lilly (Welch) | + | - | + | 8 days | 300 c.c. | + |
| E. Lederle | - | - | - | 2 days | 400 c.c. | + |
| E. Lederle | - | - | - | 2 days | 400 c.c. | + |

dogs were injected intraperitoneally with antitoxin and sterile

One lived nine days, one died in twelve to fifteen hours, and one died fourteen days before being used for another experiment. All died in eight to twenty-four hours. Two dogs were injected with bile in 11.5 c.c. per kilogram of body weight and 8.4 c.c. gram of body weight amounts and mixed antitoxin containing perfringens units and 10,000 vibron septique units. Both dogs died eight hours.

Antitoxin offered some degree of protection to guinea pigs when they were injected intramuscularly with the anaerobic dog liver organisms in that, although it did not prevent development of gas infection it decreased its severity and deferred the time of death. In contrast to the intramuscular injection of cultures of the dog liver anaerobic organisms resulted in violent gas infections eventuating in death. This appears to be contrary to the theory of Trusler and Martin²² that these organisms are nonpathogenic anaerobes producing no exotoxin, which seems to substantiate the contention of Andrews, Rewbridge, and

TABLE II

| DOG | INJECTION, INTRAPERITONEAL | DEAD OR WELL | WEIGHT IN KG. | AMOUNT PERITONEAL FLUID | CULTURE OF PERITONEAL FLUID |
|------|--|--------------|---------------|-------------------------|----------------------------------|
| 1 A | 91 c.c. human bile; sterile; 4,100 mg. bile salts | Well | 13.0 | | |
| 2 A | 150 c.c. human bile; sterile; 6,900 mg. bile salts | Well | 15.0 | | |
| 3 A | 500 c.c. human bile; sterile; 23,000 mg. bile salts | Well | 17.0 | | |
| 4 A | 200 c.c. human bile; sterile; 9,200 mg. bile salts | Dead 24 hr. | 11.3 | 175 c.c. | Pure culture, gm. + rods, no gas |
| 5 A | 100 c.c. cattle bile; sterile; 105 mg. bile salt per c.c. | Dead 12 hr. | 7.3 | 90 c.c. | Mixed culture, gas |
| 6 A | 100 c.c. cattle bile; sterile; 105 mg. bile salts per c.c. | Dead 24 hr. | 13.2 | 90 c.c. | Pure culture, gm. + rods, gas |
| 7 A | 100 c.c. cattle bile; sterile; 105 mg. bile salts per c.c. | Dead 24 hr. | 9.1 | 95 c.c. | Mixed culture, gas |
| 10 A | 100 c.c. human bile; 46 mg. bile salts per c.c. | Well | 13.0 | | |
| 11 A | 100 c.c. human bile; 46 mg. bile salts per c.c. | Well | 15.0 | | |

In three dogs the fundus of the gall bladder was amputated without tying the common bile duct; in three others the gall bladder was defundated, and the ductus choledochus was ligated and divided. These operations were performed under aseptic technique. In all six dogs, the bile, the liver, and the abdominal muscle were cultured for a gram-positive anaerobe simulating *Clostridium welchii*. The dogs died in from two to twelve days and varying amounts of hemorrhagic and bile-

TABLE III

| DOG | PROCEDURE | BILE CULTURE | MUSCLE CULTURE | LIVER CULTURE | DEATH | PERITONEAL FLUID | CULTURE PERITONEAL FLUID |
|-----|--|--------------|----------------|---------------|---------|------------------|--------------------------|
| 1 B | Gall bladder defundated | + | - | - | 2 days | 300 c.c. | + |
| 2 B | Gall bladder defundated | + | + | + | 12 days | 150 c.c. | + |
| 3 B | Gall bladder defundated | - | + | + | 7 days | 500 c.c. | - |
| 4 B | Common bile duct tied and cut Gall bladder defundated | - | + | - | 9 days | | + |
| 5 B | Common bile duct tied and cut Gall bladder defundated | - | + | + | 2 days | 300 c.c. | + |
| 6 B | Common bile duct tied and cut Gall bladder defundated | - | + | + | 2 days | 250-300 c.c. | + |

stained ascitic fluid were found. This fluid was cultured in each case. A gram-positive large rod similar to *Clostridium welchii* was found in five cases.

It would seem that, if death were due to a *Clostridium welchii* toxemia, the lethal outcome might be deferred or avoided by the administration of sufficient doses of antitoxin. Accordingly, in nine dogs the common bile duct was ligated and the gall bladder defundated and antitoxin was left in the peritoneal cavity. One dog was accidentally strangled in the cage; one lived twenty-nine days, was sacrificed, and a walled-off abscess containing bile-stained pus was found in the right upper quadrant. Six dogs died from thirty-six to forty-eight hours after operation. One lived eight days. All anaerobic cultures (brain broth) from the peritoneal cavity were positive for a gram-positive bacillus resembling *Clostridium welchii*.

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|-----|----------------------------|----------------------|------------------------|-----------------------|---------|--------------------------|-------------------------------------|
| 8B | 15 c.e. Lilly (Welch) | + | - | + | Strang. | | |
| 9B | 15 c.e. Lilly (Welch) | + | - | - | 29 days | | |
| 10B | 35 c.e. Lilly (Welch) | + | + | + | 2 days | 600 c.e. | + |
| 11B | 15 c.e. Lilly (Welch) | - | + | + | 2 days | 200 c.e. | + |
| 12B | 25 c.e. Lilly (Welch) | - | - | - | 2 days | 500 c.e. | + |
| 13B | 15 c.e. Lilly (Welch) | - | + | + | 36 hr. | | |
| 14B | 30 c.e. Lilly (Welch) | + | - | + | 8 days | 300 c.e. | + |
| 20B | 30 c.e. Lederle | - | - | - | 2 days | 400 c.e. | + |
| 21B | 30 c.e. Lederle | - | - | - | 2 days | 400 c.e. | + |

Three dogs were injected intraperitoneally with antitoxin and sterile dog bile. One lived nine days, one died in twelve to fifteen hours, and one lived fourteen days before being used for another experiment. Controls all died in eight to twenty-four hours. Two dogs were injected with bovine bile in 11.5 c.e. per kilogram of body weight and 8.4 c.e. per kilogram of body weight amounts and mixed antitoxin containing 10,000 perfringens units and 10,000 vibriion septique units. Both dogs died in eight hours.

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| 4 A | 200 c.c. human bile; sterile; 9,200 mg. bile salts | Dead 24 hr. | 11.3 | 175 c.c. | Pure culture, gm. + rods, no gas |
| 5 A | 100 c.c. cattle bile; sterile; 105 mg. bile salt per c.c. | Dead 12 hr. | 7.3 | 90 c.c. | Mixed culture, gas |
| 6 A | 100 c.c. cattle bile; sterile; 105 mg. bile salts per c.c. | Dead 24 hr. | 18.2 | 90 c.c. | Pure culture, gm. + rods, gas |
| 7 A | 100 c.c. cattle bile; sterile; 105 mg. bile salts per c.c. | Dead 24 hr. | 9.1 | 95 c.c. | Mixed culture, gas |
| 10 A | 100 c.c. human bile; 46 mg. bile salts per c.c. | Well | 13.0 | | |
| 11 A | 100 c.c. human bile; 46 mg. bile salts per c.c. | Well | 15.0 | | |

In three dogs the fundus of the gall bladder was amputated without tying the common bile duct; in three others the gall bladder was defundated, and the ductus choledochus was ligated and divided. These operations were performed under aseptic technique. In all six dogs, the bile, the liver, and the abdominal muscle were cultured for a gram-positive anaerobe simulating *Clostridium welchii*. The dogs died in from two to twelve days and varying amounts of hemorrhagic and bile-

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| 1 B | Gall bladder defundated | + | - | - | 2 days | 300 c.c. | + |
| 2 B | Gall bladder defundated | + | + | + | 12 days | 150 c.c. | + |
| 3 B | Gall bladder defundated | - | + | + | 7 days | 500 c.c. | - |
| 4 B | Common bile duct tied and cut Gall bladder defundated | - | + | - | 9 days | | + |
| 5 B | Common bile duct tied and cut Gall bladder defundated | - | + | + | 2 days | 300 c.c. | + |
| 6 B | Common bile duct tied and cut Gall bladder defundated | - | + | + | 2 days | 250-300 c.c. | + |

TABLE VI

| GUINEA PIG | INJECTION, INTRAPERI- TONEALLY | GM. WEIGHT | KILLED | ASCITES C.C. | CULTURE |
|---------------|-----------------------------------|---------------|--------|-----------------|---------|
| 11 | 10 c.c. NaCl 20%—50% glucose | 526 | 2 hr. | 30 | Sterile |
| 12 | 10 c.c. 20% NaCl—50% glucose | 550 | 4 hr. | 5 | Sterile |
| 13 | 10 c.c. 20% NaCl | 450 | 1½ hr. | 30 | Sterile |
| 14 | 10 c.c. 20% NaCl | 475 | 4½ hr. | | Sterile |
| 15 | 10 c.c. 1% HCl | 435 | 16 hr. | | Sterile |
| 16 | 10 c.c. 1% HCl | 422 | 16 hr. | | Sterile |
| 17 | 10 c.c. 20% NaCl | 512 | 1½ hr. | 23 | Sterile |

um welchii were injected intraperitoneally. Four of these dogs died in from fifteen to seventy-two hours. At post mortem were found 50 to 250 c.c. of foul-smelling ascitic fluid which was bloody, darkly hemorrhagic peritoneal and serosal surfaces, essentially the findings of bile peritonitis. Cultures of the ascitic fluid were positive for the Welch bacillus.

The remainder of the dogs, one of which was given 400 c.c. of 6 per cent acacia solution intravenously, were living after several weeks. Two dogs were injected intraperitoneally with 50 per cent glucose solution and Welch culture; both remained living and apparently well.

TABLE VII

| DOG | WEIGHT IN KG. | PROCEDURE | SUBSEQUENT COURSE |
|-----|------------------|---|-------------------|
| 36 | 8.2 | 50 c.c. Ba plus 20 c.c. Welch culture | Living and well |
| 37 | 9.6 | 50 c.c. Ba plus 20 c.c. Welch culture | Dead, 3 days |
| 38 | 10.0 | 50 c.c. Ba plus 20 c.c. Welch culture | Dead, 25 hr. |
| 39 | 12.3 | 50 c.c. Ba plus 20 c.c. Welch culture | Living and well |
| 40 | 10.0 | Ba 5 c.c./kg. plus Welch culture 2 c.c./kg. | Living and well |
| 41 | 7.5 | Ba 5 c.c./kg. plus Welch culture 2 c.c./kg. plus 400 c.c. acacia | Living and well |
| 17 | 6.8 | Ba 5 c.c./kg. plus Welch culture 2 c.c./kg. | Dead, 15 hr. |
| 39 | 11.3 | Ba 5 c.c./kg. plus Welch culture 2 c.c./kg. | Dead 29-40 hr. |
| 36A | 7.7 | Glucose 2 c.c./kg. plus Welch culture 1 c.c./ kg. | Living and well |
| 35 | 11.2 | Glucose 2 c.c./kg. plus Welch culture 1 c.c./ kg. | Living and well |

The anaerobe alone did not cause death, but apparently did so only when an irritant was given simultaneously.

It is thus seen that bile possesses some specific toxic or devitalizing action, apparently not dependent upon contained Welch bacilli or anaerobes liberated upon escape of bile into the peritoneal cavity. This specific toxic action is quantitative and appears to be due to the bile salt content of the bile.

THE FACTOR OF SECONDARY SHOCK

The remainder of our experimental work was largely directed toward repeating the work of Harkins, Harmon, Hudson, and Andrews,² who

Hrdina¹ that the organism is pathogenic and closely related to, if not identical with, *Clostridium welchii*.

Biopsies obtained from the muscles of nine guinea pigs proved sterile on anaerobic culture (brain broth); that from one guinea pig contained staphylococcus, probably a contaminant. Sterile whole bovine bile was injected intramuscularly into ten guinea pigs, in two of which antitoxin was also injected. The affected muscle was cultured upon death; no effect was apparent from the antitoxin in this series.

TABLE V

| GUINEA PIG | BILE SALTS INTRAMUSCULARLY | DEATH | GAS | ANTITOXIN | MUSCLE CULTURE |
|------------|----------------------------|-------------|-----|-----------|--------------------------------------|
| 1 | 1,700 mg. | 21 hr. | + | - | Gm. + rods |
| 2 | 1,700 mg. | 23 hr. | + | - | Gm. + rods |
| 3 | 850 mg. | 27-38 hr. | + | - | Gm. + rods |
| 4 | 850 mg. | 123-134 hr. | - | - | Not done |
| 5 | 1,700 mg. | 114 hr. | - | + | Gm. + rods <i>Str. diplococci</i> |
| 6 | 1,700 mg. | 43 hr. | - | + | Gm. + rods |
| 7 | 1,700 mg. | 2 hr. | - | - | Not done |
| 8 | 1,700 mg. | 23 hr. | + | - | Gm. + rods |
| 9 | 1,700 mg. | 22 hr. | + | - | Gm. + rods |
| 10 | 1,700 mg. | 39 hr. | + | - | Gm. + rods Staphylococci |

In every case in which cultures were taken, the muscle tissue showed gram-positive anaerobes similar in morphology and cultural characteristics to *Clostridium welchii*.

If the devitalizing action of bile salts will bring about an endogenous infection of the peritoneal cavity by *Clostridium welchii* which have been lying dormant in the tissues, an injection of other irritants should bring about the same exodus of *Clostridium welchii* with a resultant toxemia. Accordingly, hypertonic saline solution, dextrose, and hydrochloric acid were injected intraperitoneally into seven guinea pigs and the ascitic fluid subsequently cultured.

Bile therefore must have some more specific action than merely devitalizing the tissues to enable the anaerobic organism to thrive, since all these cultures were sterile. Upon injecting these irritants intramuscularly and subsequently culturing muscle biopsies, variable results were obtained, but in no instance was an organism closely resembling *Clostridium welchii* found.

Since the intraperitoneal injection of irritants other than bile failed to effect the presence of *Clostridium welchii* in the ascitic fluid of these animals, it was thought that a comparison of the post-mortem findings in bile peritonitis with those in animals that had received injections of both *Clostridium welchii* and an irritant might prove illuminating; consequently, a 50 per cent barium sulfate suspension was injected intraperitoneally into eight dogs. Simultaneously pure cultures of *Clostridi-*

In Dog 3, in addition to the above procedure, 50 c.c. of 30 per cent magnesium sulfate solution was given intraperitoneally with no apparent effect on the course of the condition.

In Dogs 5 and 6 the common bile duct was tied and the gall bladder defundated and the dogs subsequently connected to the kymograph apparatus to record the carotid blood pressure. These dogs survived longer and, with the exception of Dog 3 which had been given hypertonic magnesium sulfate, had relatively the greatest amount of exudate in the peritoneal cavity.

In Dogs 4, 7, and 8, the bovine bile or bile salt solution was injected intravenously a few cubic centimeters at a time. Following each injection, especially if it was made rapidly, there occurred a dip in the blood pressure tracing, each time dropping lower as more bile was injected.

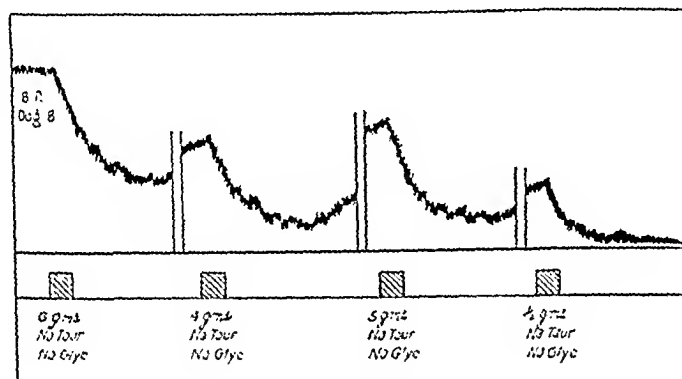


Fig. 2.

The determination of the percentage of blood volume was based upon Weleker's estimation that the blood constitutes 7.7 per cent of the body weight in dogs.²⁴ It is seen that the dogs having a massive ascites from intraperitoneal irritation have consistently an elevation of hemoglobin percentage indicating hemoconcentration from fluid loss.

The determination of bile salts in the peritoneal exudate was crude and inaccurate, due to the protein content, but, except in the two dogs which were operated upon, it was constantly low, indicating that the intraperitoneal bile was greatly diluted with body fluid. This fluid clotted spontaneously and in all except Dog 5 showed gram-positive rods upon culture. The fluid lost to the circulatory system did not form as great a percentage of the blood volume as most of Harkins, Harmon, and Hudson's cases, and it is doubtful if the loss of this fluid would be sufficient to cause death in itself; however, there is little doubt that it is an extremely important contributing factor in the causation of death in these animals.

contended that death in choleperitonium is due to shock from loss of plasma-like fluid into the peritoneal cavity; and also to attempt to find an efficacious form of treatment for the condition in experimental animals.

For the first group of experiments to check the findings of Harkins and his co-workers, we used eight apparently normal dogs. Complete anesthesia was induced by the use of sodium pentobarbital; 35 mg. per kilogram of body weight was dissolved in sterile distilled water and injected intravenously. A blood sample was taken at this time and at periodic intervals thereafter; the hemoglobin percentage was determined by a direct colorimetric method suggested by Dr. Frederick Scott. The first dog was prepared and the carotid artery exposed and cannulated, the three-way cannula being connected to a mercury manometer, so that the carotid blood pressure was constantly recorded upon a slowly revolving kymograph. One hundred forty cubic centimeters of sterile bovine bile containing 170 mg. of bile salts per cubic centimeter were injected aseptically into the peritoneal cavity. The carotid blood pressure tracing was continued until death, four hours after the injection of bile.

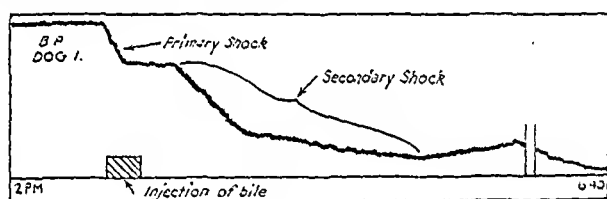


Fig. 1.

At first there was a slight drop in blood pressure, from 180 mm. of mercury mean pressure to 160 mm. Then a more gradual, profound drop to 80 mm. occurred. The blood pressure stayed then for three hours between 40 and 80 mm. of mercury before death occurred.

During this period the hemoglobin percentage rose to 120. At autopsy, 250 c.c. of darkly hemorrhagic ascitic fluid was found and cultured; gram-positive rods and staphylococci were obtained. The peritoneal and serosal surfaces were dull and boggy in appearance. The spleen was very dark, almost black, not enlarged; the liver and kidneys appeared grossly normal; there was no abnormal intravascular clotting; the adrenal cortices were grossly normal, but there were petechiae in the medullas. There was no pleural exudate and the lungs appeared normal. The heart was dilated and flabby. This was essentially the pathologic picture in all of the dogs; there were, however, small pleural exudates in two dogs that had had laparotomies.

In Dog 2 the same procedure was followed and essentially the same results were obtained.

As controls for this series of experiments, several dogs were placed in the blood pressure apparatus, the carotid cannulated, and various irritant solutions injected intraperitoneally and the blood pressure variations observed.

The primary small drop in blood pressure was always present, but no sustained, profound drop was observed comparable to that occurring when bile or bile salt solution was injected, again indicating the specificity of the action of bile in depressing the circulation. Five grams of glucose in 50 per cent solution, and 140 c.c. of hydrochloric acid in 37 per cent solution were used. At autopsy these dogs had an ascites of varying degree.

TABLE IX

| DOG | TIME OF DEATH | INTRAPERITONEAL IRRITANT | BLOOD PRESSURE DROP | HGB. % | PERITONEAL FLUID | CULTURE |
|-----|---------------|---|---------------------|------------|------------------|------------|
| 9 | Killed 4 hr. | Glucose, 5 gm. 50 per cent solution HCl 37 per cent, 140 c.c. | 90 mm. | 107 | 200 c.c. | |
| 10 | Killed 6 hr. | 45 gm. glucose 50 per cent solution | 40 mm. | 132 138 | 325 c.c. | |
| 11 | Killed 7 hr. | 25 gm. glucose 50 per cent solution | 30 mm. | 125 131 | 400 c.c. | |
| 12 | Died 3½ hr. | 50 gm. glucose 50 per cent solution | | | 360 c.c. | Gm. + rods |
| 13 | Died 20 days | 50 gm. glucose 50 per cent solution | | | | Sterile |

The high hemoglobin values and large amount of peritoneal fluid which, however, did not clot spontaneously and was not hemorrhagic, would indicate that shock should be present under these conditions; however, the drop in blood pressure was not great unless massive doses were given and, furthermore, the condition was reversible when moderate doses of the irritant were given; that is, the blood pressure in all the dogs rose to normal following the initial drop.

Eleven dogs were then injected intraperitoneally with bovine bile in amounts of 5 to 10 c.c. per kilogram of body weight. In the last four dogs a skin incision about 1 cm. long was made and the edges retracted; thus the injection was made without touching the skin.

In the others, ordinary sterile technique was used. In the last two dogs, 3 to 4 c.c. of intravenous evipal were used as anesthetic instead of sodium pentobarbital. In three dogs of this series, attempts at treatment were made by supplying fluids in the form of intravenous and subcutaneous physiologic saline solutions and transfusions of blood. In four cases in which the peritoneal effusion was cultured, gram-positive rods were present.

TABLE VIII

| DOG | PROCEDURE AMOUNT BILE SALTS AMOUNT BILE INJECTED | DEATH IN HOURS | WEIGHT IN KG. | MEAN BLOOD PRESSURE IN MM. HG | HGB. % | AMOUNT PERITONEAL FLUID C.C. | % BODY WEIGHT (FLUID LOST) | % BLOOD VOLUME (FLUID LOST) | BILE SALTS IN PERI- TONEAL FLUID | CULTURE PERITONEAL FLUID | MISCELLANEOUS PROCEDURES |
|-----|---|----------------------|---------------------|---|---------------------------------|------------------------------------|-------------------------------------|--------------------------------------|---|--------------------------------|--|
| 1 | 23,800 mg. 140 c.c. ox bile intrapertitoneal | 1 | 13.9 | 182-160-124 90-62-50 64-30 | 100 110 120 | 250 | 0.79 | 10.4 | 2.86 mg. 1 c.c. | Staph. gm. + rods | |
| 2 | 36,330 mg. 230 c.c. ox bile intrapertitoneal | 8 | 21.0 | 166-142-120 140-150-114 106-76-64 48 | 127 137 137 139 147 | 450 | 1.05 | 13.6 | 2.58 | Staph. Strep. gm. + rods | |
| 3 | 11,750 mg. 47 c.c. dog bile intrapertitoneal | 2+ | 18.6 | 178-150-140 122-113-132 138-110-80 88-70 | 128 135 125 | 360 | 1.08 | 21.8 | 3.62 | Strep. gm. + rods | 50 c.c. 30% MgSO ₄ 1 P. |
| 4 | 18,700 mg. 110 c.c. ox bile intravenous | 2+ | 15.5 | 168-140-150 90-120-140 62-124-40 64 | 85.8 78.7 | 50 | | | 0.7 | Strep. Staph. gm. + rods | |
| 5 | Gall bladder defundated, com- mon bile duct tied and cut | 26 | 27.0 | 68-52-46 | 124 | 370 | 1.37 | 17.8 | 41.0 | Strep. Staph. | |
| 6 | Gall bladder defundated, com- mon bile duct tied and cut | 22 | 11.4 | | 128 | 175 | 1.53 | 19.9 | 32.5 | Strep. gm. + rods | |
| 7 | 6,930 mg. 35 c.c. dog bile intravenous | 3 | 22.5 | 162-120-76 108-76-54 66-52-28 | 81.6 76.9 | None | | | | Strep. gm. + rods | Injected in re- peated small doses |
| 8 | 15,500 mg. 200 c.c. salt solu- tion intravenous | 3 | 23.6 | 134-60-78-46 78-90-36-48 60-30 | 94 86 | None | | | | Staph. gm. + rods Strep. | Repeated small doses |

TABLE XI

| UNTREATED DOGS | | | DOGS TREATED ACACIA | | | |
|----------------|------------------|----------|---------------------|------------------|-----------------------|-----------|
| DOG | BILE/KG. C.C. | DEATH | DOG | BILE/KG. C.C. | 6% ACACIA, C.C. | DEATH |
| 43 | 10 | 6 hr. | 42 | 10 | 400 | 7½ hr. |
| 45 | 10 | 7 hr. | 44 | 9 | 350 | 25 hr. |
| | | | | | 250 | |
| 47 | 9 | 6 hr. | 46 | 9 | 250 350 | Living |
| | | | | | 250 | |
| 49 | 9 | 5-6 hr. | 48 | 9 | 250 | 18 hr. |
| | | | | | 250 | |
| 51 | 9 | 3-4 hr. | 50 | 9 | 250 | 13-17 hr. |
| | | | | | 250 | |
| 54 | 8 | 4 hr. | 52 | 8 | 250 250 | Living |
| | | | | | 250 | |
| 55 | 8 | 9-19 hr. | 53 | 8 | 250 | 3 days |
| | | | | | 250 | |
| 56 | 8 | 5 hr. | 57 | 8 | 250 | Living |
| | | | | | 250 | |
| 58 | 8 | Living | 60 | 8 | 250 | Living |
| | | | | | 250 | |
| 59 | 8 | 13 days | 61 | 8 | 250 | Living |
| | | | | | 250 | |
| 62 | 9 | 5-12 hr. | 63 | 9 | 250 | Living |
| | | | | | 250 | |
| 64 | 9 | 3½ hr. | 66 | 9 | 250 | Living |
| 65 | 9 | 6 hr. | 67 | 9 | 250 | Living |
| 35 | 9 | 2 hr. | 41 | 9 | 350 | Living |
| 36 | 9 | 6-8 hr. | 57 | 9 | 350 | Living |
| 40 | 9 | 7-19 hr. | 58 | 9 | 300 | Living |

Of the dogs which were given acacia solution slowly intravenously, eleven were living several weeks after injection, and five died from seven and one-half hours to three days following the induction of choleperitoneum. This experiment seems to confirm the contention that shock due to fluid loss from the circulatory channels must be a factor in the causation of death in bile peritonitis, and it also indicates the therapeutic value of intravenous isotonic colloid solution in the treatment of this condition in dogs.

CONCLUSION

From our experiments we have concluded that there are at least two factors operative in the causation of death in choleperitoneum; that is, the primary injury to the peritoneum by the toxic bile salts, and the secondary shock from loss of fluid from the vascular system. The toxic effect of absorbed bile and the bacterial factor may be of importance but, if so, they are probably only contributory to the lethal outcome.

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TABLE X

| DOG | WEIGHT IN KG. | BILE INJECTED C.C./KG. * | TREATMENT | DEATH | AMOUNT PER FLUID C.C. | % BODY WEIGHT FLUID LOST | % BLOOD VOLUME FLUID LOST | OTHER PROCEDURE |
|-----|------------------|-----------------------------|---|-----------|--------------------------|--------------------------------|---------------------------------|--------------------------------------|
| 16 | 9.8 | 8 | 100 c.c. saline intravenous 300 c.c. blood intravenous | 5 hr. | 350 | 3.3 | 46.4 | |
| 17 | 6.8 | 5 | | Well | | | | |
| 19 | 10.0 | 10 | | 6-8 hr. | 250 | 1.5 | 19.5 | |
| 20 | 11.8 | 10 | | 4 hr. | 200 | 0.7 | 9.0 | |
| 21 | 12.7 | 10 | 100 c.c. saline intravenous 300 c.c. saline subcutaneous | 15 hr. | 165 | 0.3 | 4.0 | |
| 22 | 12.0 | 10 | | 2 hr. | 150 | 0.25 | 3.3 | |
| 23 | 11.5 | 10 | | 4 hr. | 300 | 1.6 | 20.5 | |
| 24 | 13.0 | 10 | 150 c.c. saline intravenous 100 c.c. blood intravenous | 6-15 hr. | 320 | 1.5 | 19.0 | Skin in- cision |
| 25 | 14.0 | 10 | | 6-15 hr. | 400 | 1.85 | 24.1 | Skin in- cision |
| 26 | 10.4 | 7 | | Well | | | | Skin in- cision, 3 c.c. evipal |
| 27 | 13.6 | 7 | 200 + c.c. blood intravenous | 24-36 hr. | 250 | 1.1 | 14.8 | Skin in- cision, 4 c.c. evipal |

*Bile contained 105 mg. of bile salts per c.c.

If shock due to loss of plasma-like fluid is a factor in the causation of death in bile peritonitis, then the supplying of fluid in sufficient amounts, containing protein comparable in quantity to plasma, might obviate the fatal outcome or alter the disease in some manner; however, it is probable that such fluid should be supplied before the irreversible shock syndrome becomes established in order to get the maximum effect. A series of dogs were treated with intravenous injection of 6 per cent acacia solution (Eli Lilly and Co.) in order to supply a fluid which would not be apt to escape into the tissues. This acacia was given in divided doses, usually spread over a considerable length of time and starting soon after injection of the sterile bile. A parallel series of dogs were used as controls; these animals were given the same dosage of bile as the other dogs, but received no treatment. Intravenous acacia solution was the only therapy any of these dogs received.

Thus it is seen that in the series of dogs with bile peritonitis induced by the injection of sterile ox-bile and left untreated, fourteen dogs died in three to nineteen hours after onset of the condition; one remained living and well, and one died thirteen days after injection.

SUBPHRENIC ABSCESS

A MEDICAL REVIEW

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NOT INFREQUENTLY, especially in hospital practice, the physician or surgeon is called upon to make or disprove the diagnosis of subphrenic abscess. With few exceptions this is a difficult problem and the diagnosis is often doubtful until pus is found at operation in the subphrenic space. As a means of studying this disease, a review has been made of the 59 proved cases of subphrenic abscess which have occurred in the Toronto General Hospital during a ten-year period since Jan. 1, 1927. Of these 59 cases, 52 were public ward cases and 7 were private cases.

ETIOLOGY

All the subphrenic abscesses of this review had their primary source in the abdominal or pelvic cavities. They occurred following:

TABLE I

| | |
|--|------------------------|
| 1. Appendicitis | 19 cases (32 per cent) |
| a. with localized peritonitis or abscess | 13 cases |
| b. with generalized peritonitis | 6 cases |
| 2. Perforated duodenal ulcer | 14 cases (24 per cent) |
| a. proved cases | 11 cases |
| b. unproved cases | 3 cases |
| 3. Perforated gastric ulcer | 3 cases (5 per cent) |
| 4. Perforated gall bladder | 2 cases (3 per cent) |
| 5. Upper abdominal operation on stomach and gall bladder | 12 cases (20 per cent) |
| 6. Pelvic inflammation | 4 cases (7 per cent) |
| 7. Colectomy, right side | 1 case (2 per cent) |
| 8. Perforated large bowel (amebic dysentery) | 1 case (2 per cent) |
| 9. Unknown | 2 cases (3 per cent) |
| 10. Undetermined (private case) | 1 case (2 per cent) |

These figures are in agreement with those of other investigators^{1, 2} in that lesions of the appendix and perforated gastric and duodenal ulcers accounted for the majority of the cases. Little mention is made in the literature of subphrenic abscesses which have arisen following upper abdominal operations on stomach and gall bladder. But in our series this was a relatively common primary source of infection: 20

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TABLE II

| | ANTERIOR | POSTERIOR | DOVE | MASSIVE | UNDETERMINED LOCATION | TOTAL |
|--------------|----------|-----------|------|---------|--------------------------|-------|
| Right side | 13 | 17 | 10 | 2 | 2 | 44 |
| Left side | 2 | 2 | 3 | 2 | 2 | 11 |
| Bilateral | | | | | | 2 |
| Undetermined | | | | | | 2 |

In this series of cases subphrenic abscesses arising from disease of the appendix were usually located posterior, while those arising from lesions of upper abdominal organs were more frequently anterior or dome abscesses. Lesions of the appendix, gall bladder, and duodenum caused 80 per cent of the subphrenic abscesses occurring on the right side. Abscesses from lesions in these organs rarely occurred on the left side and, when they did occur, were usually associated with a generalized peritonitis. Left-sided subphrenic abscesses were most frequently caused by lesions of the stomach, such as perforated gastric ulcer, or following gastrectomy.

SYMPTOMS

Symptoms were recorded in 36 of the 52 public ward cases. In the remaining 16 cases the records were too incomplete for careful analysis as far as symptomatology was concerned. The general symptoms produced by subphrenic abscesses, such as weakness, sweating, loss of appetite, vomiting, occasionally chills, etc., are too variable and too commonly associated with suppurative conditions elsewhere in the body to be of any real value in localizing the infection to the subphrenic space.

The local symptoms found in this series were of great value in directing attention to the subphrenic space as the site of the inflammatory process. Pain of various types was the most important of these symptoms. Pain of at least one type was present in 33 of the 36 cases. Pleural pain was noted in 11 cases. It was present in the lower chest and usually most marked laterally. It tended to be of relatively short duration, lasting in most cases not longer than a week. Shoulder-tip or diaphragm pain occurred in 7 cases and was usually an early symptom and transient in character. Aching pain in the lower chest or along the costal margin was recorded in 16 cases. It appeared as a later symptom and, once present, usually remained until the abscess was drained. Pain in the upper quadrant was observed in 7 cases, in all of which the abscesses were located on the right side. In 3 of these 7 cases the abscesses were anterior and extended as a mass in the right upper quadrant from under the costal margin. Pain in the flank was present in 3 cases, 2 of which were of posterior abscesses, the other a dome abscess. This pain was aching in character and tended to remain until drainage was established.

per cent of the cases followed such operations. A probable explanation for this increase is the larger number of upper abdominal operations performed in recent years. Subphrenic abscess arose from the pelvis in four cases, the primary cause being pelvic cellulitis, pelvic peritonitis following miscarriage, abdominoperineal resection of the rectum, and repair of cystocele and rectocele.

Cases of subphrenic abscess which have arisen from a primary source in the thorax have been reported in the literature.^{3, 4} Most of these have been due to empyema, basal lung abscess, or bronchiectasis. Septicemia, which was present in a few of our cases, has been cited^{1, 3} as a source from which infection has reached the subphrenic space. However, none of the subphrenic abscesses of this review arose either from the thorax or from a septicemia.

LOCATION

Accurate anatomic descriptions of the subphrenic spaces have been given by Martinet⁵ and Barnard.⁶ In his excellent paper Barnard depicts the subphrenic region as being divided on each side into three sections, and, according to the relationship of each section to the peritoneum, they are termed the anterior and posterior intraperitoneal spaces and the extraperitoneal space. Most writers on the subject of subphrenic abscess have made use of this classification. However, it was not used in this study since, in many of our cases, it was impossible to localize the abscess with sufficient accuracy, even after operation. This is to be expected since in surgical drainage the subphrenic abscess was opened usually from its most accessible site, and it was neither possible nor advisable to determine its entire extent.

In this review subphrenic abscesses have been classified for practical purposes according to their relationship to an imaginary line drawn in the coronal plane of the body through the dome of the diaphragm. A line so drawn will divide the subphrenic space into two parts on each side. Abscesses situated mainly anterior to this line and pointing anteriorly were designated as "anterior." Similarly, those which were situated mainly posterior to this line and pointing posteriorly were classified as "posterior." In several cases the abscesses were centered mainly on this imaginary line or under the dome of the diaphragm and these have been designated as "dome." In a few cases the abscesses were so extensive as to be posterior, anterior, and dome; these have been termed "massive." Massive in this instance refers to the extent of the abscess rather than to the quantity of pus it contained.

According to this classification, the location of subphrenic abscesses in the 59 cases reviewed was as follows:

Diminished movement of the chest, impaired resonance, and altered breath sounds are the common triad of signs in cases of subphrenic abscess. The latter two occurred in more than 80 per cent of this series of cases.

VALUE OF PHYSICAL SIGNS IN LOCALIZATION

Efficient surgical drainage is a necessity in the successful treatment of a subphrenic abscess. Such efficient drainage is greatly facilitated by a knowledge of the maximum location of the abscess. Signs helping to localize the abscess as anterior were: first, the signs of impaired resonance, etc., found in the chest were higher anteriorly than posteriorly in 8 out of 15 cases of anterior abscess; second, in 4 cases of the 15 anterior abscesses tenderness was present anteriorly and in 3 of these a mass could be felt in the upper abdomen. However, all anterior abscesses had physical signs posteriorly, and in many cases physical signs were of little value in determining the maximum location of the subphrenic abscess.

FEVER

Temperature readings taken at the time of diagnosis, or a few days before death where clinical diagnosis was not made, have been compiled in 48 cases in which the subphrenic abscess was considered to be the dominant condition present. Of this group, 86 per cent had a well-marked elevation of temperature (over 101° F.); 10 per cent had slight elevation (under 100° F.); and in 4 per cent there was a normal temperature. The fever generally was remittent or intermittent in character and the temperature charts tended to fit into two types: (1) a group of cases which had a low grade temperature postoperatively for five to ten days, then a gradual elevation of temperature which became swinging or septic in character; (2) a group of cases having high fever postoperatively which continued or increased and became septic in type.

LEUCOCYTE COUNT

The leucocyte counts were estimated in 37 cases within a few days of the time the subphrenic abscess was proved. In 70 per cent of these cases a leucocytosis was present with a count of over 12,000 white blood cells per cubic millimeter: the majority of these were over 15,000. Approximately 25 per cent of the cases had leucocyte counts under 11,000 and in 2 cases the count was normal. It is significant that each of these cases with normal leucocyte counts had a temperature of 102° F.

X-RAY EXAMINATION

X-ray films or fluoroscopic examinations were made use of in 36 of the 52 public ward cases. The variability of the findings is well illustrated by Table III.

Cough proved to be a difficult symptom to evaluate since most of the patients with subphrenic abscess had had operations for the primary condition, frequently done under general anesthesia. Many of these patients had cough postoperatively for several days, often due to either bronchopneumonia or postoperative collapse. In such instances the cough could not be attributed to or definitely related to the subphrenic abscess. In 6 cases, however, the cough was present when the abscess was well developed and appeared to be related to the subphrenic abscess. The cough was unproductive in 1 of these cases and productive in 5. The sputum was small in amount, mucoid in 3 and mucopurulent in 2 cases. Compression or basal collapse of the lung was the likely cause of the sputum and cough.

Hiccough, which other investigators^{2, 7} have commonly found, was noted in only 2 of our cases. In 1 it proved to be very distressing and was present continuously for twelve days.

PHYSICAL SIGNS

These were recorded accurately in 46 cases and may be divided into those chiefly found in the thorax and those chiefly abdominal.

A. *Thoracic Signs.*—The most common physical finding was impaired resonance in the lower chest. This usually went as high as the inferior angle of the scapula posteriorly, and tended to extend anteriorly into the axilla and to a slightly lower level in the anterior chest. This more or less horizontal area of impaired resonance was present in 38 of the 46 cases (82 per cent). In this area of impaired resonance tactile fremitus was absent and the breath sounds decreased in intensity in all cases. The breath sounds were absent in 10 cases, diminished in 19, decreased bronchovesicular in 2, and distant bronchial in 6. At the upper part of this area of impaired resonance and decreased breath sounds, râles were recorded in 8 cases (17 per cent). A pleural friction rub was also heard in 7 cases (15 per cent). This was a relatively early finding and did not last longer than one week. Shifting dullness and succussion splash were found in the lower chest in 1 case only, where fluid and air were present in the subphrenic abscess. An unusual sign observed in 1 case in which the subphrenic abscess had been present for two years was clubbed fingers.

B. *Abdominal Signs.*—Tenderness in the right upper abdominal quadrant was present in 7 cases, in 6 of which the abscess was anterior while in the seventh it was posterior. In 3 of these cases a mass was found in the right upper quadrant, indicating the position of the abscess. Tenderness in the costovertebral angle was present in 6 cases, 4 of which were posterior abscesses but 2 were anterior abscesses. Subcutaneous edema also was present in the costovertebral angle and around the flank in only 3 cases. Downward displacement of the liver was recorded in only 4 cases.

which the abscess was drained within twenty-six days, but two weeks later ruptured into a bronchus. The drainage had been inadequate.

Rupture into Pleural Cavity.—This complication developed in 6 cases (13 per cent), and these do not include 2 cases in which a small amount of pus spread into the pleural cavity when a subphrenic abscess ruptured into a bronchus. Rupture into the pleural cavity, on the average, is an earlier complication than rupture into a bronchus. In 5 cases in which accurate dates were available, it took place between fourteen and thirty-five days after the onset of the abscess.

DIAGNOSIS

The duration of the subphrenic abscess from the probable time of onset to diagnosis has been recorded in 51 cases in which accurate dates were available. The two shortest time intervals were in subphrenic abscesses due to perforated duodenal ulcers and were five and eight days. The longest duration was two years in a case in which the primary cause was probably a perforated duodenal ulcer. Thirty-nine of the 52 public ward cases were correctly diagnosed, and of these the average time to diagnosis was twenty-seven days. Many of these cases required relatively long periods of observation to exclude other diagnoses before the true nature of the condition was recognized.

Thirteen public ward cases were incorrectly diagnosed. In 12 of these accurate dates were available and the average duration from onset to diagnosis, by autopsy or fatal complication, was forty days. These 13 cases were divided into two groups, as follows:

1. Subphrenic abscess was undiagnosed in 7 cases, or not diagnosed until within a few days of death when some complication developed which made the correct diagnosis apparent. Four of these abscesses ruptured into lung and bronchus; 1 ruptured into the pleural cavity. Two cases had other fatal infections; 1, septicemia; and 1, pyelophlebitis.

2. In 6 cases the diagnosis was incorrectly made and proved at post-mortem examination or operation to be a subphrenic abscess. Of these 1 case was diagnosed as collapsed left lower lobe; 2 were diagnosed as pleural effusion. In 1 of the latter a pleural effusion was found secondary to a subphrenic abscess, and in the other case no pleural effusion was present. Three cases were diagnosed as empyema. In 2 of these the pleural cavity was normal; in the third an effusion was present secondary to a subphrenic abscess.

All of these 13 cases terminated fatally. In 9 of them a fatal outcome might have been avoided by an early and correct diagnosis.

Diagnostic Aspiration.—Aspiration through the diaphragm as a method of diagnosing subphrenic abscess has been advocated and condemned by various writers for many years. In 7 of our cases a needle was inserted either accidentally or intentionally through the diaphragm. In 6 cases pus was found, but in the seventh case a negative result was

TABLE III

| X-RAY FINDINGS | NO. OF CASES | PERCENTAGE |
|---|--------------|------------|
| High diaphragm (no record of movement) | 15 | 42 |
| Diaphragm high and fixed | 8 | 22 |
| Diaphragm high with restricted movement | 4 | 11 |
| Diaphragm, normal position; no record of movement | 2 | 6 |
| Diaphragm in normal position with diminished movement (right anterior lateral) | 1 | 3 |
| Diaphragm moving freely; no record of its position (right anterior lateral) | 1 | 3 |
| Diaphragm not visualized, due to pleural effusion | 5 | 14 |
| In the above cases gas and fluid were found beneath the diaphragm: perforated ulcer, 5; gastrectomy, 2; appendicitis, 1 | 8 | 22 |

In this series of cases subphrenic abscess occurred when the diaphragm was in normal position or when it had normal movement, but in no instance were both these findings present together. It is seen from the above figures that x-ray examination is of definite value as an aid to history and physical examination in the diagnosis of subphrenic abscess.

THORACIC COMPLICATIONS

Of all the complications of subphrenic abscess, those occurring in the thorax are the most frequent and are very likely to cause serious or fatal consequences. In 45 subphrenic abscesses the thoracic complications have been listed in their order of frequency.

Pleural Effusion.—A pleural effusion occurred in 14 cases (31 per cent). Of itself it was not serious, but greatly increased the difficulty of diagnosing the subphrenic abscess and in 9 of the 14 cases an empyema developed. A pleural effusion was not necessarily a late complication. This was shown by the fact that 3 cases developed an effusion within a week of the probable onset of the subphrenic abscess. The development of pleural effusion following an infective lesion in the abdominal cavity, especially relating to stomach, gall bladder, duodenum, or appendix, should demand that the possibility of a subphrenic abscess be considered.

Rupture into Lung and Bronchus.—This was a serious and usually fatal complication. It happened in 6 cases (13 per cent), and in only 1 case did recovery take place. In 5 instances it occurred on the right side and in 1 case on the left. Lung abscess developed in 3 cases and a septic pneumonia in another. Rupture into a bronchus was largely a late complication and, with the exception of 1 case in which it took place in ten days after the probable onset of the subphrenic abscess, always occurred after forty days, or later, in 1 case two years. The case in which rupture occurred in ten days demonstrates the fact that diagnosis of subphrenic abscess should be made early in order that this complication may be avoided. That adequate drainage is also essential in preventing this complication was illustrated by one case in

a primary source of infection resulting in a subphrenic abscess. Special attention should be given to lesions of the duodenum, stomach, gall bladder, and appendix, since lesions of these organs account for such a high percentage (84 per cent) of the cases.

CONCLUSIONS

1. All 59 cases of subphrenic abscess reviewed had a primary source in the abdomen or pelvis; 84 per cent originated from lesions of the duodenum, appendix, stomach, and gall bladder; 7 per cent arose from the pelvis.

2. In 75 per cent of our cases the abscess was located on the right side; 19 per cent were on the left side; 3 per cent were bilateral; and in 3 per cent of the cases the position was undetermined. The abscess was posterior in 32 per cent of the cases; anterior in 25 per cent; over the dome of the diaphragm in 22 per cent; and in 7 per cent of the cases it was massive, involving all regions of the subphrenic space.

3. Lesions of the appendix, gall bladder, and duodenum caused 80 per cent of the subphrenic abscesses occurring on the right side. Left-sided subphrenic abscesses were most frequently caused by lesions of the stomach, such as perforated gastric ulcer or following gastrectomy.

4. Lesions of the appendix caused most of the posterior abscesses, while lesions of the duodenum and gall bladder were the primary cause of the majority of anterior abscesses.

5. The commonest and most important symptom pointing to a subphrenic abscess was pain. Cough and sputum appeared to be of little value in diagnosis.

6. The most common thoracic findings were diminished movement, altered tactile fremitus, impaired resonance in the lower chest, and altered breath sounds. The last two findings were noted in over 80 per cent of this series.

7. Physical findings in the abdomen were much less common than those found in the chest. Tenderness in the upper abdomen was present in 9 per cent, while a mass could be felt in 6 per cent. Costovertebral tenderness was found in 13 per cent and subcutaneous edema in only 6 per cent. The liver was found displaced downward in only 9 per cent of the cases.

8. It was difficult to localize the abscess either anteriorly or posteriorly in many cases. Thoracic signs were more prominent anteriorly than posteriorly in 53 per cent of cases where the abscess was anterior. In all abscesses, thoracic signs were present posteriorly. Abdominal signs in the right upper quadrant occurred in anterior abscesses as follows: tenderness in 26 per cent; a palpable mass in 20 per cent.

obtained from an aspiration done posteriorly. Later, a subphrenic abscess was drained anteriorly in this case. One case developed empyema of the pleural cavity following, and possibly due to, diagnostic puncture.

The presence of subphrenic abscess which was not found by diagnostic aspiration and the possible production of an empyema of the pleural cavity show the unreliability and danger of this method of examination. In our opinion it should never be used with one possible exception; that is, in an extremely ill patient where an incorrect diagnosis of subphrenic abscess with a resulting unnecessary operation might be fatal. Under these circumstances it may be wise to do a diagnostic aspiration, but it should be done on the operating table and, if pus is found, surgical drainage of the abscess undertaken at once. With this possible exception, diagnostic aspirations should not, in our opinion, be undertaken.

MORTALITY

The total mortality of the 59 cases in this series was 28, 47 per cent. This figure is not strictly representative of the mortality of subphrenic abscess alone, since 10 of the 28 fatal cases had one or more of three associated conditions; namely, septicemia, generalized peritonitis, multiple abdominal abscesses. In these 10 fatal cases the subphrenic abscess was not likely or necessarily the primary cause of death. If these 10 cases are excluded from the series, the mortality of the cases in which a subphrenic abscess was the primary cause of death is 31 per cent.

Thirty-nine cases of subphrenic abscess in this series were operated upon for drainage of the abscess. Of these, 9 died, giving an operative mortality of 23 per cent. This operative mortality is not applicable to subphrenic abscess as the predominant condition, since 4 of the 9 fatal cases had associated conditions which were equal or greater factors in the cause of death. Two of the cases had septicemia and 2 had multiple abdominal abscesses. If these 4 cases are removed from the statistics, the operative mortality of the cases in which a subphrenic abscess was the primary cause of death becomes 13 per cent.

DISCUSSION

Subphrenic abscess presents a most difficult problem in diagnosis. This is shown by the number of cases incorrectly diagnosed and by the length of time required to make a correct diagnosis. Often associated with late diagnosis is the development of serious complications, most of which are related to the thorax. Rupture into the lung and pleural cavity are relatively frequent events where diagnosis is delayed.

After a review of these cases, it seems imperative to direct attention to earlier diagnosis. The value of a careful history and thorough physical examination cannot be stressed too greatly in a consideration of this disease. Any infective or suppurative lesion in the abdomen or pelvis, especially if it is associated with free infected fluid, may be

THE PALMAR FASCIA IN CONNECTION WITH DUPUYTREN'S CONTRACTURE

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THE study of the palmar fascia was undertaken with the intention of throwing more light on the cause of flexion deformity of the fingers observed in Dupuytren's contractures. In reviewing the literature it was found that the description of the palmar fascia with all its dependencies was not always very clear and varied a great deal in textbooks.

The present study was mainly based on multiple dissections of hands in different age groups and on review of literature.

The palmar aponeurosis is an irregular triangular sheet found under the skin of the palm of the hand; its base is directed toward the metacarpophalangeal joints; its apex is continued with the tendon of the palmaris longus, in cases where the palmaris longus is present. According to LeDouble, the palmaris longus is absent in 11.2 per cent of subjects. When the palmaris longus is absent, the apex of the palmar aponeurosis is found at various levels of the wrist, adhering either to the annular ligament or to the antibrachial fascia. The palmar fascia is limited externally by the thenar and medially by the hypothenar aponeurosis. These last structures are much thinner than the central portion. The palmar aponeurosis consists of longitudinal and transverse fibers.

LONGITUDINAL FIBERS

The longitudinal fibers have a double origin. The more superficial and more abundant fibers continue the palmaris longus tendon. The deeper longitudinal fibers continue the annular ligament. These last fibers have an oblique direction and form two groups; one group goes from the medial part of annular ligament toward the metacarpophalangeal joint of the index finger. The other group, coming from the lateral side of the annular ligament, is going toward the metacarpophalangeal joint of the fifth finger. Thus, these two groups cross in the form of a letter X and are situated directly under the superficial longitudinal fibers (see Figs. 1 and 4). The superficial longitudinal fibers form a divergent sheet of uneven thickness. Over the flexor tendons of the second, third, fourth, and fifth fingers the sheet is more dense and forms four bands. These bands were named pretendinous bands by Leguen and Juvara, who gave an excellent description of the fascia of the hand in 1892. These pretendinous bands may vary in num-

9. X-ray examination, including fluoroscopy, was a valuable aid to diagnosis. A high diaphragm, either fixed or with restricted movement, was found in 75 per cent of the cases.

10. Diagnostic aspiration of the subphrenic space should seldom be done.

11. Pleural effusion occurred in 31 per cent of the cases; empyema of the pleural cavity in 15 per cent; rupture of abscess into a bronchus in 13 per cent; rupture into the pleural cavity in 13 per cent.

12. The mortality in all cases where the subphrenic abscess was the primary cause of death was 31 per cent. The mortality of the cases operated upon was 13 per cent.

13. Earlier and more accurate diagnoses could have materially reduced this mortality rate.

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they are especially marked over the metacarpophalangeal joints. Some of these fibers are attached to the proximal and middle phalanges of the fingers on their volar surface and also on the lateral side, forming two distinct lateral bands (see Fig. 1). These bands are described by several anatomists and are illustrated well by Frazer in *The Anatomy of the Human Skeleton*. They were also noticed by Dupuytren. However, these bands are not constant. It should be mentioned here that the attachment of these bands to the phalanges apparently gave reason to consider the palmar aponeurosis as a terminal tendon of the palmaris longus and as a remnant of a subcutaneous flexor of the fingers. This last view is contested. M. Ferrarini, of the Anatomical Institute of the University of Pisa, found that the palmaris longus is of a very late phylogenetic development and that the various structures of the palmar fascia are not a uniform embryological entity.

Second Group.—The second group of fibers is directed toward the deep interosseous fascia. They encircle the flexor tendons, forming regular

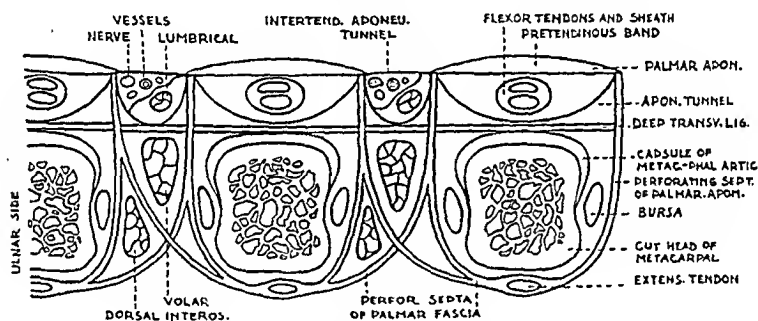


Fig. 2.—Redrawn and modified from Leguen and Juvana. Schematic cross section of the hand through the metacarpal heads to show the arrangement of the third group of perforating fibers of the longitudinal pretendinous bands.

tunnels for the tendons. Similar and separate tunnels are formed around the lumbricals and the digital nerve and vessels. These tunnels are found only under the middle third of the palmar fascia between the distal border of the ulnar bursa and the deep transverse ligament. These tunnels are of unequal length, the longest one surrounding the flexor tendon of the index finger and the shortest surrounding the fourth finger. The little finger usually has no tunnel, the length of the tunnels being dictated by the length of the flexor tendons which are not covered by the sheath of the ulnar bursa distally and the digital bursae of the fingers. The volar surface of the ulnar bursa intimately adheres to the palmar aponeurosis in its proximal third and over the flexor tendon of the little finger (see Fig. 5).

Third Group.—The third group of fibers are called the perforating fibers. They can be observed only over the heads of the metacarpals; detached from the borders of the deep surface of the pretendinous bands, they are directed straight downward from the palm of the hand to the

ber. In an article published recently by Kalberg, the number of pretendinous bands was found very variable; instead of the usual four, he found five, six, and seven. He also found that the number of these bands may differ in the hands of the same individual. Between the pretendinous bands are found the intertendinous bands which are less dense. The fibers of the intertendinous bands are intimately connected

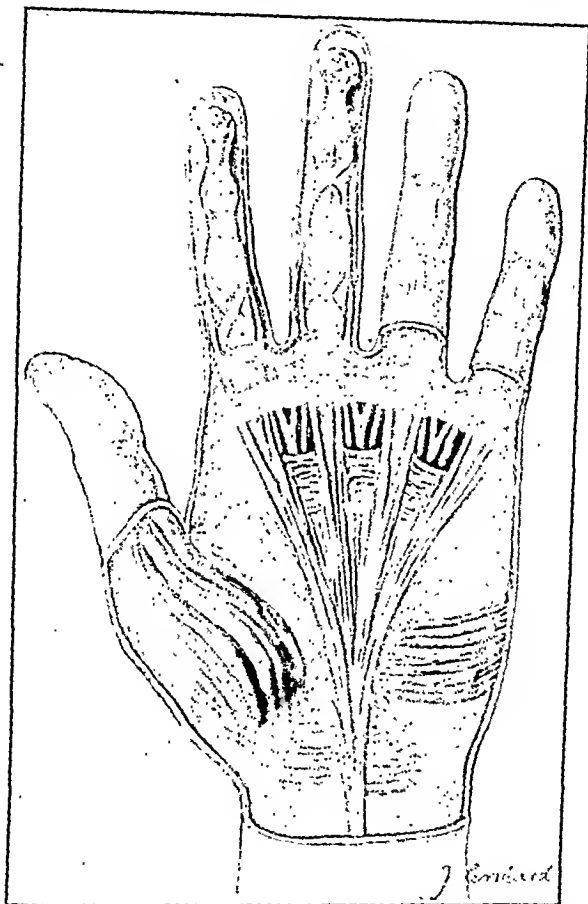


Fig. 1.—Four pretendinous bands are shown with digital prolongations forming two lateral bands around the proximal phalanx. The digital vessels and nerves are usually covered by these bands; they are also covered by the thin superficial transverse ligament and are only visible for a short distance in the spaces between the pretendinous bands. The oblique fibers crossing in the form of a letter X are seen emerging from the sides of the palmar fascia. The superficial transverse ligament is shown proximal to the ligamentum natatorium. They are both represented denser than seen in reality.

with the skin of the palm of the hand. The termination and insertion of the pretendinous bands is complex and can be divided into three distinct groups.

First Group.—The fibers of the first group go to the deep surface of the skin of the palm along the entire length of the pretendinous bands;

a number of short and long fibers which extend from one finger to another and which are attached to the fibrous sheaths of the fingers or to the deep surface of the skin of the fingers; other fibers are in continuation with the longitudinal digital prolongations of the palmar aponeurosis; according to Frohse the natatory ligament limits the flexion of a finger when the nearest fingers are in extension."

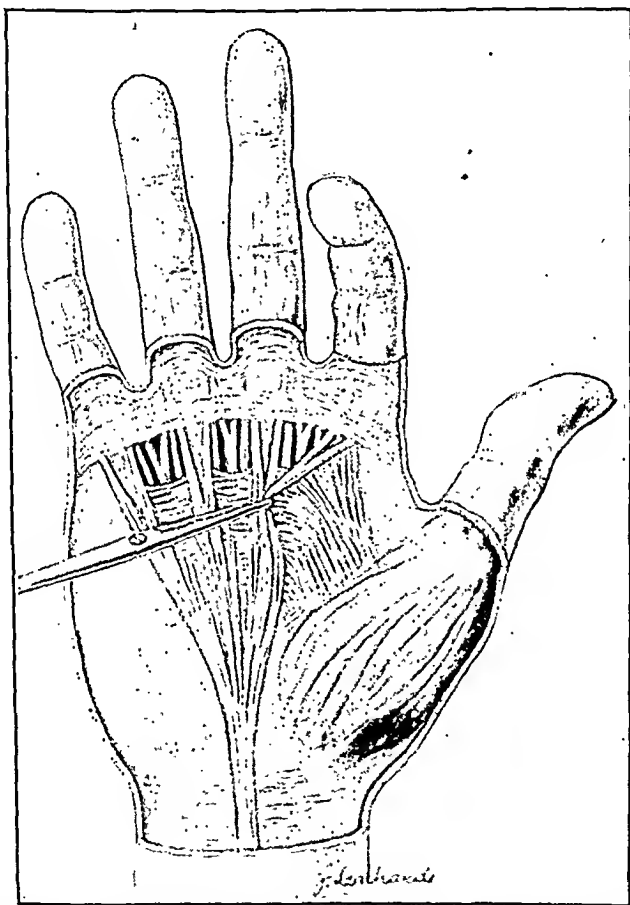


Fig. 3.—Palmar fascia after removal of skin. The ligamentum natatorium and the superficial transverse ligament are shown. Traction on the pretendinous band of the index finger shows flexion of the proximal and middle phalanges.

It is generally considered that for the successful treatment of Dupuytren's contracture it is necessary to remove the entire palmar fascia, including the penetrating septa which form tunnels around the tendons, nerves, vessels, and lumbrical muscles of the hand. However, numerous surgical observations in patients afflicted with Dupuytren's contractures indicated that the contracture of the palmar aponeurosis did not extend down to the subaponeurotic expansions (to the second and third group of fibers as described above).

dorsum between the metacarpal heads (see Fig. 2); they perforate the deep transverse ligament, form separate sheaths for the interosseous muscles, and surround the head of the metacarpals on both sides, becoming connected with the dorsal aponeurosis of the hand. While passing between the metacarpal heads, they do not adhere to the periosteum of the metacarpal head. They are sometimes separated from the periosteum by a small bursa. This is frequently observed in children. It is well known that the palmar aponeurosis is separated from the thenar and hypothenar aponeuroses. There exists between the radial border of the palmar aponeurosis and the thenar aponeurosis a dense septum which is attached to the volar crest of the third metacarpal and which separates the thenar muscles and forms the lateral border of the middle palmar space. This septum is so constructed in certain cases that the flexor tendons of the index with the first lumbrical are left within the thenar space, being in a more or less intimate connection with the adductor of the thumb. DeLorme has given a description of this area. The investigations of Kanavel showed that clinically this is more frequently observed than the other anatomical arrangement in which the flexor tendons of the index are wholly within the midpalmar space. On the ulnar side, a much thinner septum is present between the hypothenar muscles and the ulnar border of the aponeurosis. This septum, attached to the anterior crest of the fifth metacarpal, separates the ulnar side of the middle palmar space from the thenar muscles.

TRANSVERSE FIBERS

The transverse fibers of the palmar aponeurosis are situated under the longitudinal fibers and are more developed at the distal part of the palmar aponeurosis. Over the metacarpal heads a real transverse ligament can be observed. Poirier named this ligament, by analogy to the deep transverse ligament, the superficial transverse ligament of the hand. This ligament has no distinct proximal border but is very distinctly separated distally and forms a visible border about 1 cm. proximal to the webs of the fingers. In the area just below the webs of the fingers Grapow described a structure which he named the "ligamentum natatorium" (see Fig. 1). The superficial transverse ligament is extended from the external tubercle of the second metacarpal head to the internal tubercle of the fifth metacarpal head. Certain fibers go around these metacarpal heads and may become attached to the extensor tendons; shorter fibers extend over the intertendinous spaces of the palmar aponeurosis only. The ligamentum natatorium is thus described by Poirier: "Its proximal border is transverse and is very distinctly separated from the distal border of the superficial transverse ligament; between the two borders there is a distance of at least 1 cm. The distal border of the natatory ligament corresponds to the volar surface of the phalanges and to the web spaces. This ligament is constituted by

the palmar fascia which was previously dissected from the skin was very carefully dissected from the underlying structures: the annular ligament, tendons, lumbrical muscles, and vessels. The deep extensions of the palmar aponeurosis going toward the interosseous fascia were not excised. The palmar fascia was lifted up but was left attached by its base distally. Each pretendinous band was grasped on its deeper surface with a forceps and pulled in the same direction as in the previous

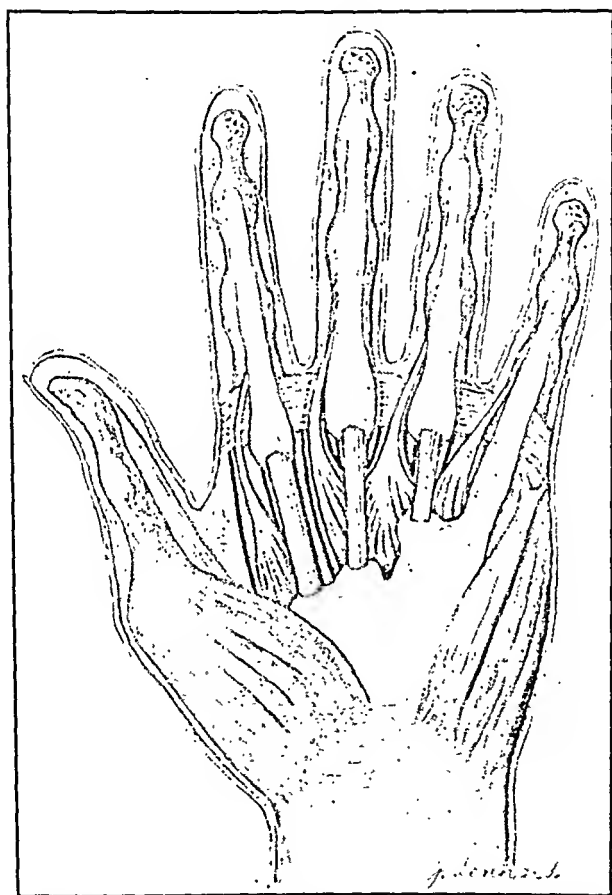


Fig. 5.—The schematically shown heavy black lines between the tendons show how the second group of the pretendinous bands penetrate between the tendons and also show their unequal length. The heavy black line between the index and medius shows the separation of the midpalmar space from the thenar space.

experiment. It was found that the traction produced a strong flexion of the corresponding proximal phalanx (see Fig. 4). This experiment was repeated on several hands and produced positive results invariably, except in those cases where no digital prolongations could be found (first group of fibers). On the basis of this study, it was concluded that the flexion contracture of the fingers which is observed in the Dupuytren's syndrome is probably due almost exclusively to the contracture of the

To investigate this problem, the following experiments were carried out: A careful dissection of the palmar skin was done, separating it from the palmar aponeurosis up to the web of the fingers. The skin was reflected and the palmar aponeurosis was carefully exposed but was left intact. With the fingers held in extension, each pretendinous band was grasped separately with a forceps and pulled in a proximal direction.

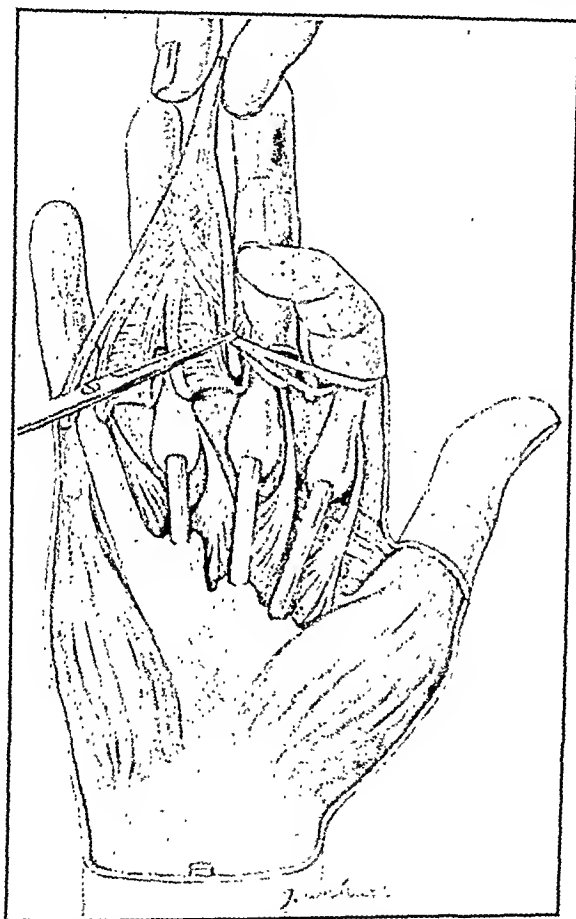


Fig. 4.—The palmar fascia separated from the underlying structures and lifted up shows on the undersurface the oblique fibers. The traction on the pretendinous band shows the flexion of the proximal and middle phalanx.

The pulling invariably produced a slight flexion of the corresponding proximal and sometimes proximal and middle phalanges (see Fig. 3). In those cases where the pulling of the pretendinous bands did not produce a flexion of the proximal phalanx, it was observed that no trace of a digital prolongation of the pretendinous band could be found. A similar traction of the dissected and reflected skin, in the axis of the fingers, never produces a flexion of the corresponding fingers. Subsequently,

MIXED TUMOR OF THE PAROTID GLAND WITH METASTASIS

A CASE REPORT

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IN SPITE of many interesting and ingenious theories devised to explain the origin and nature of the mixed tumor of the salivary glands, we still must consider them as being among those tumors most apt to behave in an unexplained and unexpected manner. Few subjects in the field of oncology have aroused more controversy, and at the same time have remained so obscure in regard to the fundamental facts of their natural history. Ewing¹ has written that no single source of the mixed tumors meets all the requirements, and it is equally true that there are no criteria which will enable us safely to predict for them a benign course, local recurrence, or distant metastases. Some observers have felt that certain histopathologic characteristics were sufficient to differentiate between the clinically benign and clinically malignant growths, but, after a careful study of three hundred cases, McFarland² expressed the opinion that their histopathologic appearance could not be correlated with their clinical behavior. Satisfactory evidence supports his viewpoint.

These seemingly innocent tumors are notorious for their tendency to recur after local excision, and, according to Neill,³ the incidence of recurrence in the parotid group was, until twenty years ago, sometimes as high as 75 per cent. It is encouraging to note that in more modern reports this figure is considerably lower. In Kemmon's⁴ series it was 15.5 per cent, and in Benedict and Meigs⁵ cases 30 per cent recurred locally after operative removal. McFarland, whose large series certainly must be a satisfactory sample upon which to base statistical studies, reported local recurrence in 23 per cent of his patients. The constantly high incidence of this unfortunate phenomenon has made the surgical treatment of these lesions unsatisfactory. At present, however, other therapeutic measures give results that are even more unsatisfactory.

In contrast to recurrence, it is quite generally agreed that metastasis is a rare event in the natural history of mixed tumors. Porter and Churchill⁶ found in the literature eight cases of mixed tumors of the parotid with well-authenticated metastases. In six of these the spread was through the blood stream (Bridde, Chiari, Foerster, LeClere, LeDentu, and Payne), while in the remaining two instances (Brandes and

phalangeal insertions of the pretendinous bands of the palmar aponeurosis and has little or nothing to do with the deep extensions of the palmar aponeurosis toward the deep interosseous fascia. It may be suspected that Dupuytren's syndrome may develop only in those cases where the digital prolongations of the pretendinous bands are present.

SUMMARY AND CONCLUSION

A study of the palmar fascia was made with the intention of discovering which part of the palmar aponeurosis is mostly responsible for the flexion contracture of the fingers. It was found that only the longitudinal fibers were responsible for the flexion and that the removal of the longitudinal fibers only, without removing the deep extensions of the fascia, might be sufficient for cure.

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slow, gradual growth, which had been accelerated considerably during the year before admission. This lesion had never been productive of pain or discomfort nor had it interfered with the movements of the mandible.

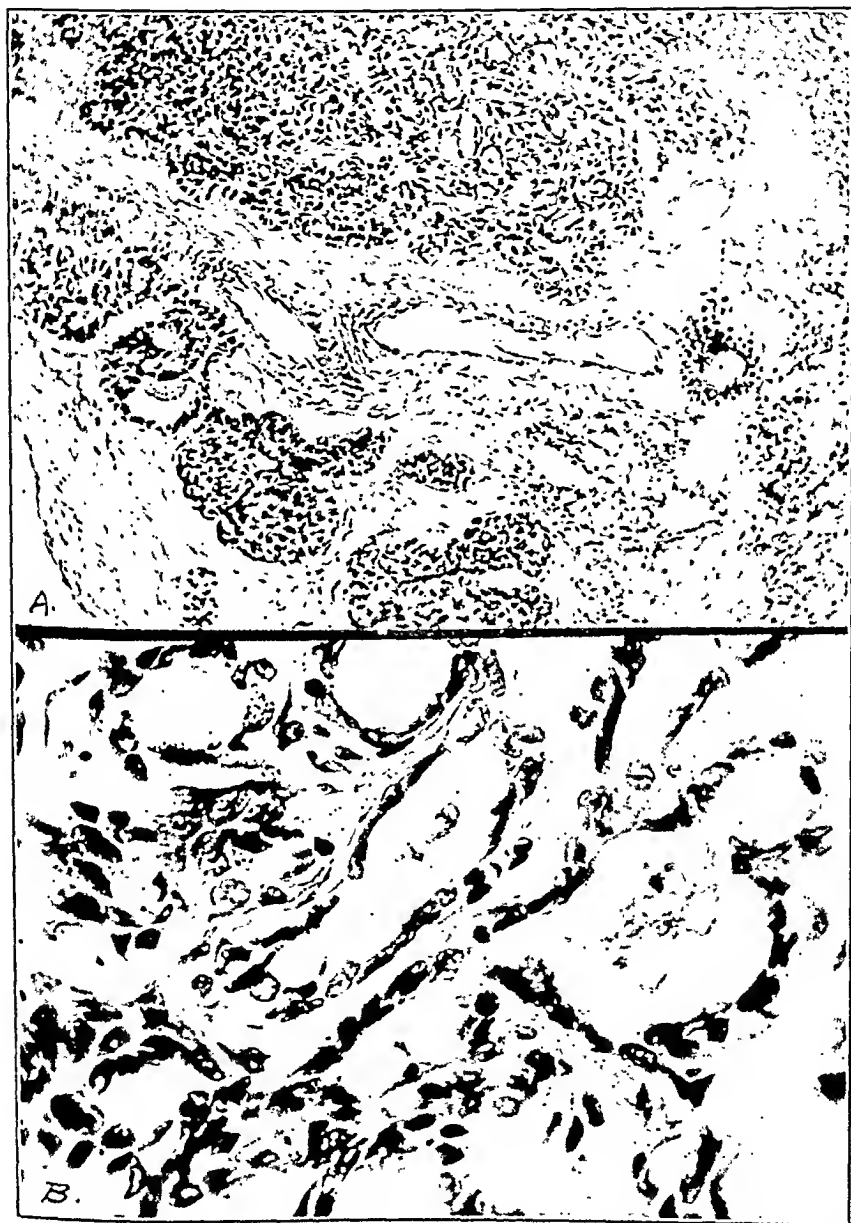


FIG. 1.—A, Photomicrograph (low power) of parotid tumor; B, photomicrograph (high power) of parotid tumor.

Examination.—In the region of the right parotid gland was a large, hard, lobulated mass whose measurements were 6 cm. by 10 cm. by 15 cm. It crowded the ear posteriorly and outward and extended down into the neck. Neither skin

Wood) the secondary deposits were in the cervical lymph glands. The case observed by Griffini and Tronbetta (cited by McFarland⁸) had metastatic lesions in the bones. In addition to these cases many others are mentioned by McFarland in his review of the literature. Those least objectionable from the standpoint of correct diagnosis are the following: Two cases with cervical lymph gland metastases reported by Nasse; Partsch's case of "cylindroma" of the parotid with metastases to the pleura; a similar case with cranial metastases reported by Rispoli and Samiac; and another patient who had multiple metastatic lesions of the skin, observed by Fargue, Morgue-Molmes, and Villa. A patient with a degenerated mixed tumor of the parotid upon whom Kammerer⁹ operated died three and one-half years after operation with liver deposits. Olson⁹ found described in the literature four cases of mixed tumor in which secondary growths were proved to be present in the lungs, and to these he added three similar cases of his own. In two of Olson's cases aberrant salivary gland tissue was the source of the tumor and in the third the original lesion was in a salivary gland and metastasized to the sternum as well as the lung. Fitzwilliams¹⁰ patient had metastases in the deep cervical glands, lungs, and pleura. Other cases have been reported in which the nature of the primary tumor is in doubt and it is not improbable that in some of the above cited cases the same criticism may be justified.

Whether or not carcinomatous or sarcomatous change is always present in the primary mixed tumor before metastases may occur is a highly controversial question. McFarland believes that it is not necessary to explain the clinically malignant course of some tumors on the basis of carcinomatous or sarcomatous degeneration, but that such behavior is an inherent tendency of these growths. The statement that "malignant change, whether 'sarcomatous' or 'carcinomatous,' in mixed tumors must be rare and its occurrence difficult to prove," summarizes his opinion quite accurately. Wood,¹¹ however, considered the metastatic lesions in two of his cases to be purely sarcomatous; Porter and Churchill believe that the secondary lesions arising from mixed tumors of the parotid are usually of carcinomatous structure. They evidently did not consider it inconsistent to think that mixed tumors metastasize through the blood stream rather than to the regional lymph nodes.

The patient whose illness we are to report is interesting because she furnishes a good illustration of some viewpoints which have been cited above and also because of some unusual features.

CASE REPORT

On June 11, 1934, a white female patient, 47 years of age, was admitted to the Christian B. Holmes Hospital on the service of Dr. Mont B. Reel. According to her history, a tumor had been present, posterior to the angle of the right mandible, during a period of five years. At first quite small, this mass had undergone a

of hyalinized intercellular stroma. The cells were growing rather wildly, with alveolar arrangement in some places and no definite grouping in others. No mitotic figures were found. (Fig. 1.)

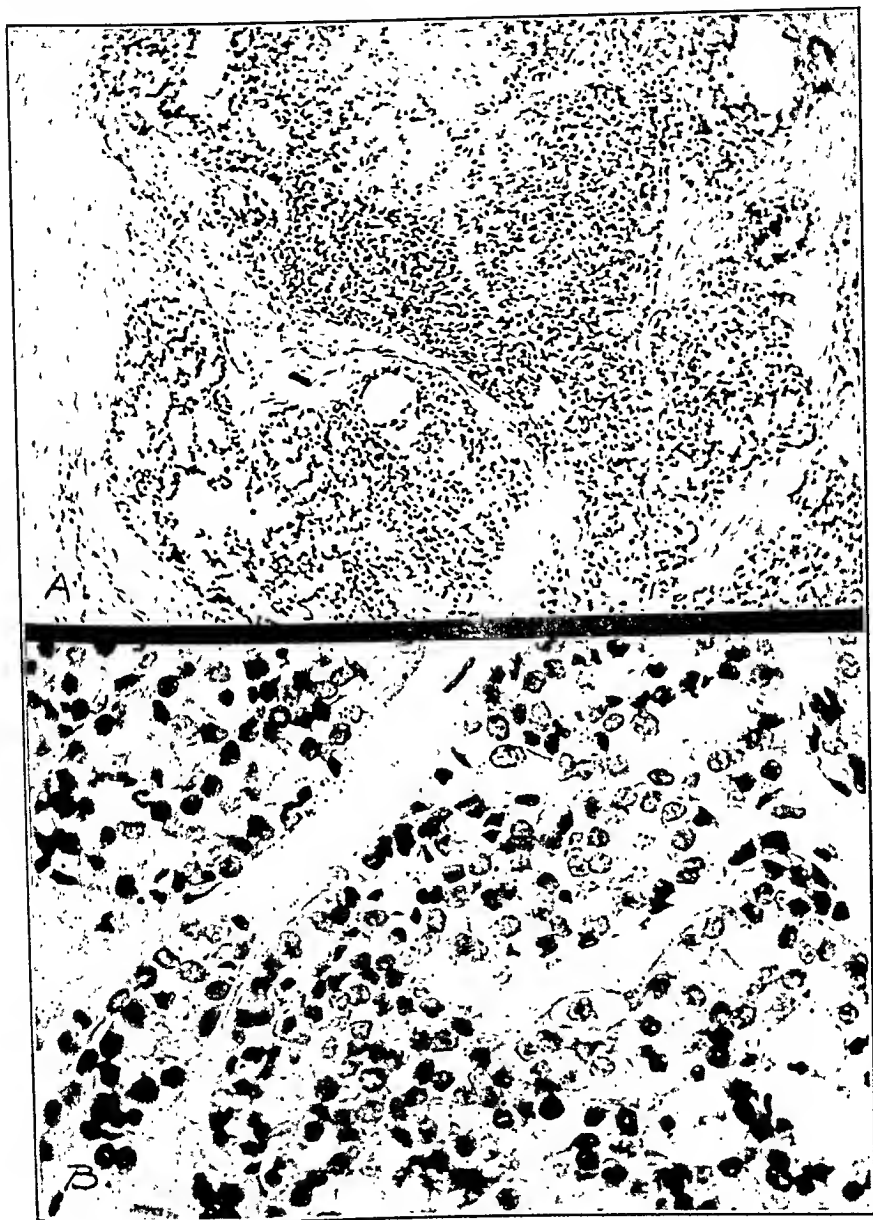


FIG. 1.—*A*, Photomicrograph (low power) of metastatic tumor of anterior abdominal wall; *B*, photomicrograph (high power) of metastatic tumor of anterior abdominal wall.

After the operation, the wound healed per primum and there was no evidence of facial nerve injury. On the third postoperative day the patient was allowed to leave the hospital.

attachment nor fluctuation could be demonstrated and the mass was movable on its underlying structures. The general physical examination did not reveal any pathology of importance. A clinical diagnosis of mixed tumor of the parotid gland was made without reservation.

On the day after admission, the patient was operated upon under local anesthesia. The incision was made from just below the zygomatic arch to below the angle of



Fig. 2—A, Anteroposterior view showing destructive lesion of second lumbar vertebra; B, lateral view showing destructive lesion of second lumbar vertebra.

the jaw, extending over the apex of the tumor. When the tumor was exposed, it proved to be a hard, encapsulated, nodular mass lying superficial to the facial nerve and presenting no gross evidence of malignant degeneration. In dissecting out the tumor, great care was used to remain outside the capsule, and after the excision was completed there was no evidence of injury of the tumor capsule or the facial nerve. All bleeding points were ligated with black silk and the skin was closed with the same material.

The pathologist reported that the lesion was an encapsulated mixed tumor of the parotid presenting highly cellular epithelial areas, interspersed with large areas

3. Histopathologic evidence of carcinomatous or sarcomatous degeneration was present in neither the primary nor the metastatic tumor.

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We had no further information concerning this patient until quite recently, when a letter was received from her physician. The communication stated that her final illness had begun in December, 1936, two and one-half years after her operation. The first symptom was the development of a progressively more severe pain in the lumbar and sacral regions, and when she was examined in April, 1937, tenderness over these areas was the only significant finding. There was no evidence of local recurrence in the face or neck. Starting in the early part of September, 1937, there was severe radiation of the pain down the left leg and thigh, a symptom which was greatly aggravated by movement of the extremity. X-ray examination of the spine showed that this pain was due to a lesion which had caused almost complete destruction of the body of the second lumbar vertebra (Fig. 2). Very soon after this a subcutaneous tumor about the size of an egg was discovered on the abdominal wall below the left costal margin. This tumor had not been found at the time of the previous examination three weeks before. The lesion was surgically removed and slides made from its tissue were prepared for microscopic examination. Another lesion was discovered on Oct. 3, when a rectal examination was made because of a partial intestinal obstruction. This consisted of a hard mass felt high up in the pelvis. A few days before the death of the patient, on Oct. 18, 1937, a subcutaneous tumor was found on the left thigh.

The physician in charge of the patient was kind enough to send us one of the slides made from the metastatic growth on the anterior abdominal wall. Careful examination of the slide confirmed our belief that this lesion was the result of a metastasis from the mixed tumor of the parotid. Although its individual cells are neither as large nor as dark staining as those of the original tumor, the arrangement is similar and the same hyalinized intercellular material is present (Fig. 3). We do not believe that a diagnosis of carcinomatous or sarcomatous degeneration can be made either from the original tumor or from the metastatic lesion.

COMMENT

This case may be regarded as an exception to the rule that mixed tumors recur locally before giving rise to metastases. Of course, the period which elapsed between the date of operation and the time of death (three years, four months) is not sufficiently long to rule out the possibility of a local return of the growth, as McFarland has reported that recurrence may take place as late as forty-seven years after excision. It is entirely possible that a very small local recurrence may have escaped detection. The fact that histopathologic evidence of malignant degeneration was not apparent in either the primary or secondary growth is not unusual and agrees very well with the theories and observations of some other investigators.

SUMMARY

1. The incidence of distant metastases from a mixed tumor of a salivary gland is rare, as is shown by a brief review of the literature. In this paper such a condition occurring in a 47-year-old female patient is reported. The primary tumor was in the parotid gland.

2. The tumor did not recur locally, but three years after removing the primary lesion metastatic growths occurred in the anterior abdominal wall, the lumbar spine, pelvis, and subcutaneous tissue of the thigh.

3. Histopathologic evidence of carcinomatous or sarcomatous degeneration was present in neither the primary nor the metastatic tumor.

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LIPIODOL IN THE TREATMENT OF PERSISTENT FECAL FISTULA AFTER APPENDECTOMY

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THE treatment of fecal or postappendiceal fistula presents an interesting though perplexing problem. Operative treatment is occasionally hazardous, while conservative treatment frequently meets with stubborn failure to heal. Where the patient is a poor surgical risk, or where there is danger of contamination in surgical intervention, the only recourse is conservative treatment and the outlook often is pessimistic. For this reason, the two cases herein reported should be of interest. They suggest a new therapeutic measure, namely, introduction of lipiodol through the fistulous tract, which is worthy of further clinical trial.

CASE REPORTS

CASE 1.—K. G., a 65-year-old white housewife, was operated upon on July 6, 1934, at which time an acutely gangrenous and perforated appendix was found. The wall of the cecum was markedly involved with an acute inflammatory process. The appendix was removed and drainage was instituted. Four days following the operation the wound "broke down" and a discharge of fecal material ensued. Conservative treatment was instituted (administration of a low-residue diet and small enemas), but with no success so far as the closure of the fistula was concerned. After a stormy postoperative course, the patient was discharged on Sept. 4, 1934, with a draining fecal fistula. Before attempting to close the fistula surgically, it was decided to examine the extent, character, and course of the fistulous tract by roentgenography. For that purpose, a catheter was introduced into the fistula and lipiodol was injected. The x-ray examination revealed that "the sinus tract extends downward and inward toward the pelvis and opaque material entered the rectal pouch near its proximal portion" (Fig. 1). Immediately after this procedure, we noted a considerable diminution in the amount of fecal material exuding from the fistula and hence the operation was delayed. Complete constipation was induced by the use of tincture of opium minims three times daily, and the patient was placed on a liquid diet. Subsequently another 5 c.c. of lipiodol was injected into the tract. Within one week after the initial injection of lipiodol, the tract had closed. The patient was discharged on Nov. 27, 1934.

CASE 2.—A. G., a 55-year-old white housewife, was operated upon on Nov. 6, 1936, at which time an acute suppurative appendicitis was found and two drains were inserted. The patient had a rather stormy course with elevated temperature and was given a transfusion of 300 c.c. of blood on the eighth day postoperative. She was discharged Dec. 20, 1936, with a small amount of fecal drainage from the wound. On Feb. 4, 1937, she was again operated upon in an attempt to close the fistula. The operation was unsuccessful and the drainage continued.

On Oct. 1, 1937, she was readmitted to the surgical service. Thorough catharsis for two days was followed by numerous cleansing enemas. After an injection of lipiodol through a catheter inserted into the fistulous tract, x-ray examination revealed "the sinus tract to extend posteriorly and medially." (Fig. 2.) "It is about 6 cm. in length and communicates with a rather large abscess cavity measuring about 4 by 3 cm."

As in the first case, immediate diminution of the fecal outflow through the tract followed the injection of lipiodol. Four further injections of from 3 to 5 c.c. of lipiodol were given at two- to three-day intervals. The fistula was completely occluded within ten days.

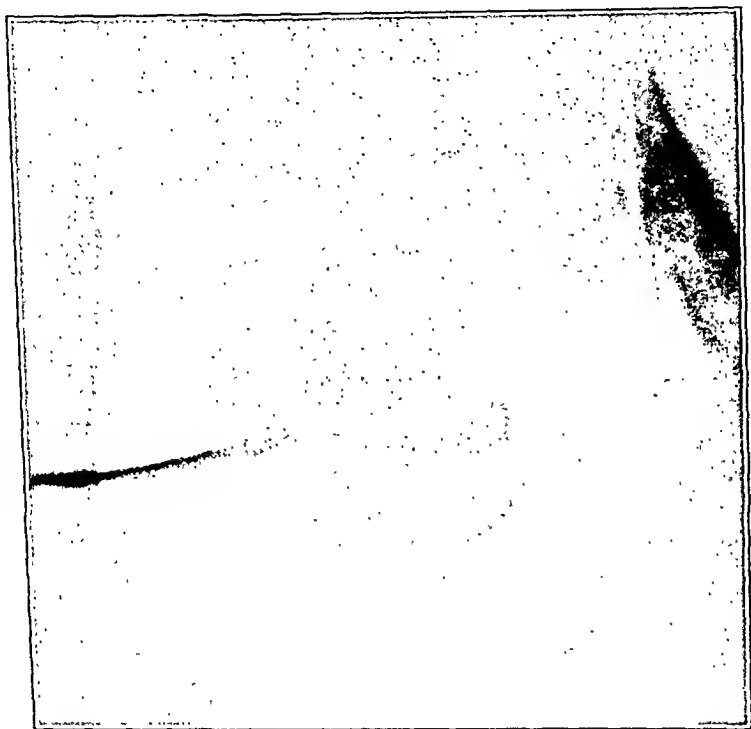


Fig. 1.—Lipiodol injection of the sinus tract in Case 1. The sinus tract extends downward and inward toward the pelvis and opaque material enters the rectal pouch near its proximal portion.

DISCUSSION

A fecal fistula consists of an outgrowth of mucous membrane from the wall of the gut which becomes continuous with the skin, thus forming a permanent canal through which a portion of the contents of the large bowel may escape. The condition is generally seen following inflammatory involvement of the wall of the cecum or ileum with necrosis and perforation. Another factor to which it has been attributed in some cases is opening of the appendiceal stump subsequent to appendectomy. This incidentally, has given rise to a controversy as to the wisdom of invaginating the appendiceal stump.

Although the literature contains numerous references to this distressing condition and emphasizes the dangers of operative interference, there are but few recent references dealing with the conservative management of these cases. Ransom and Collier, in a relatively recent report, discussed a series of ninety-four cases of fistula associated with or following appendectomy, which were treated by a variety of procedures. They conclude that operative procedure should be attempted only after failure of prolonged conservative treatment.



Fig. 2.—Iliodol injection of the sinus tract in Case 2. After an injection of Iliodol through a catheter, the sinus tract is seen to extend posteriorly and medially. It is about 6 cm. in length and communicates with a rather large abscess cavity measuring about 4 by 3 cm.

It is generally agreed that the majority of fecal fistulas close spontaneously after ten to fourteen days of conservative treatment. This consists of inducing peristalsis below the site of the fistula (avoiding cathartics), giving small enemas, and feeding a low-residue diet. The outlet of the fistula is occluded either by plugging the or or by approximating its edges by pressure.

It is the remaining group, in which the fistula persists despite a long trial of the above described treatment, which constitutes the problem. The two cases presented, one of over four months' duration, and the other of almost a year, with an unsuccessful attempt at surgical intervention in the latter case, healed perfectly after several injections of lipiodol into the sinus tract. This is especially interesting in view of the observations of Ransohoff and Heiman that lipiodol is of value in the treatment of empyema cavities. While these two cases do not constitute proof of the efficacy of lipiodol in this condition, they do suggest that the procedure is worthy of further clinical trial.

We are indebted to Dr. Archie Fine and Dr. Samuel Brown for the roentgenographic studies of the patients whose cases are reported here.

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AN UNUSUAL COMPLICATION FOLLOWING SUBOCCIPITAL CRANIECTOMY*

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THE purpose of this communication is the presentation of an unusual complication which may follow intracranial operations upon the cerebellum.

CASE REPORT

N. S., No. 126488, a white male house painter, aged 32 years, was admitted to the Graduate Hospital on the service of Dr. J. C. Yaskin, May 4, 1936. His chief complaint was pain in the back of the neck. In May, 1935, the patient, while wrestling, sustained a sudden twist to his neck. Following this accident, he suffered from twinges of pain poorly localized in this region. By December, 1935, the discomfort in the neck was almost constant and was aggravated by motion and by straining, as in lifting heavy objects.

After thorough physical and neurological studies, the only abnormalities noted were infected ethmoid and maxillary sinuses, for which operative procedures were instituted. He was discharged from the hospital improved.

The patient was readmitted to the hospital May 5, 1937, with the same symptom of pain in the back of the neck. In addition to this complaint he developed, during the several months before admission, headache, dimness of vision, and some subjective vertigo. He evidenced some difficulty in speaking. No history of convulsions or unconscious periods was obtained.

Neurological examination on this admission disclosed lateral nystagmus, bilateral papilledema, right-sided Babinski sign, absent ankle jerks, and a spinal fluid pressure of 330 mm. of water. A space-taking intracranial lesion, presumably in the posterior fossa, was suspected and on May 20, 1937, a ventriculogram was performed. The lateral and third ventricles were symmetrically enlarged in normal position. The diagnosis of a possible cerebellar tumor was made, and on the same day the operation of suboccipital craniectomy was performed under avertin anesthesia.

The operation was attended with a great deal of difficulty because of the patient's very short, thick neck. Adequate exposure was well-nigh impossible since flexion of the head upon the chest caused respiratory embarrassment. The cerebellar tonsils were seen to enter the spinal canal and the left cerebellar lobe was larger than the right. Aside from this no other evidence of tumor was found. Bleeding was controlled by the use of silver clips. The patient made a rapid postoperative convalescence and was discharged from the hospital June 12, 1937, with practically all symptoms relieved. Before discharge he received 2,750 r. of roentgen therapy to the posterior fossa.

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On Sept. 14, 1937, he returned to the neurological clinic complaining of pain in the lateral aspect of both thighs, intensified by movement, exertion, and coughing. He had experienced fleeting pains in the thorax and abdomen since his operation, but these were not as severe as the present thigh pains. Examination at this time revealed no papilledema, bilateral nystagmus, equal but very active knee jerks, normal ankle jerks, a right-sided Babinski sign, and areas on the lateral aspects of both thighs which were hypalgesic to pinprick (Fig. 1). The hypalgesic zones corresponded to the regions in which there was a complaint of "spontaneous" pain. Roentgen examination of the dorsolumbar spine on Sept. 16, 1937, revealed two silver clips (Fig. 2), presumably in the dorsal portion of the subarachnoid space, one at the level of the first lumbar vertebra, and the other at the level of the third lumbar vertebra. He was given an analgesic to control the pain and instructed to return for readmission.

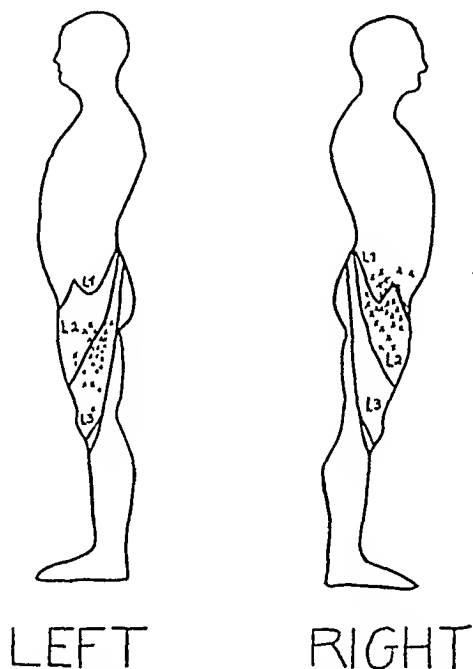


Fig. 1.—Diagrammatic representation of distribution of hypesthetic areas marked by *x* and the segmental relationship.

The patient re-entered the hospital on Oct. 11, 1937. He stated that the pain in his thighs was much relieved, but that he was generally weak and had dimness of vision and headache.

Physical examination at this time revealed lateral nystagmus and a right-sided Hoffman sign. Coincident with the diminution of the pain in the thighs, the areas of detectable hypalgesia were absent on the thighs.

Roentgen studies of the lumbar spine at this time revealed the silver clips to be in approximately the same position as in the previous study.

COMMENT

This patient demonstrates root irritation caused by silver clips which had worked themselves loose from their points of attachment and

migrated down the spinal subarachnoid space. The clips were used to control bleeding during an operation upon the cerebellum for suspected tumor.

A review of the anatomic structures of the subarachnoid space will show how such a foreign body descends from the posterior fossa to its position in the spinal canal. The arachnoid passes from the lower portion of the cerebellum to the medulla oblongata forming a triangular space beneath, called the cisterna magna. As this membrane passes down the



Fig. 2.—Anteroposterior and lateral roentgenograms of spine showing silver clips opposite the first and third lumbar vertebrae.

spinal canal, it is in close relationship to the dura. The space between the arachnoid and the pia mater is filled with cerebrospinal fluid. This space is divided into smaller communicating cavities by loosely formed connective tissue bands extending between the arachnoid and pia mater opposite the posterior median sulcus as well as the anterior median sulcus. Another subdivision is formed by the dentate ligament which connects the pia mater, arachnoid, and dura mater with the lateral surface of the spinal cord. The arachnoid itself follows along the spinal

nerves to a point just before the anterior and posterior roots unite outside the vertebral column. Thus a niche is formed at the exit of each root between it and the dentate ligament. At any one of these points a foreign body such as a silver clip may lodge. Furthermore, in almost every instance, the arachnoid enclosing the cisterna magna is torn during operations upon the posterior fossa so that clips which work loose have free access to the spinal subarachnoid space.

In our patient, the hypesthesia found in the areas to which pain was referred was caused by either lesions of the dorsal roots or the posterior horns of the gray matter in the spinal cord. The roentgen studies showed the lesions to be silver clips lying on the dorsal roots. The migration of silver clips in the subarachnoid space following cranial surgery is not a rare circumstance. The wonder is not that it occurs at all, but that it does not occur more often. The unusual features of this case are the extent of the migration, which is greater than has previously been noted with but one exception, in a patient in which there were no symptoms of root irritation. The second unusual feature is the fact that the silver clips caused symptoms of dorsal root irritation.

We presume that the fleeting pains in the thorax and abdomen, which occurred before the pains in the thighs, were caused by irritation of the posterior roots as the silver clips passed down the subarachnoid space. Likewise, the pain in the thighs was thought to be due to root irritation of the respective lumbar dorsal roots.

Editorial

Surgical Bacteriology

THE progress of surgery in the last fifty years has been made possible by the development of the science of bacteriology. The surgical approach to any part of the body is always made with the risk of introducing organisms which may gain a foothold, producing an infection with a more or less extensive destruction of tissue which may lead to the death of the patient.

In any general surgical service one-quarter to one-third of the cases may be classified as surgical infections, and in the office practice of any surgeon the proportion of infections is even greater. These statements make it almost self-evident that a surgeon, in order to practice his specialty with intelligence and success, must have a comprehensive understanding of the general principles of bacteriology and particularly the laboratory and clinical behavior of those organisms which are responsible for necrotizing or pyogenic infections. Extensive clinical experience often will make it possible for the surgeon to guess correctly the nature of the causative organism in the majority of surgical infections, but just as laboratory tests in many of the medical disorders minimize the percentage of error in diagnosis, cultural studies will make more exact the diagnosis in all types of surgical infection. Methods must be available to the surgeon and members of his staff to determine with accuracy the bacterial flora in any given case. Not infrequently, there is a mixture of organisms active in the lesion, or certain organisms which are present may be susceptible to specific therapy. This is particularly true because of the recent development and success of sulfanilamide in hemolytic streptococcus infections, of zinc peroxide in anaerobic infections, and bacteriophage in staphylococcus and *B. coli* infections.

Hospitals should be equipped with laboratories and personnel with expert knowledge of bacteriologic diagnostic methods; for example, the dark-field microscope, apparatus for anaerobic as well as aerobic bacterial cultivation, and media which are necessary to reveal the higher bacteria and fungi.

Anyone who has an opportunity to go about among hospitals in general finds, however, that many surgeons have very little appreciation of the necessity for more detailed knowledge of bacteriology; or, if they have, they complain about the limitations of the service which is rendered by the hospital. Time and time again, cases come into the hospital with extensive surgical infections, some acute and some long standing, in

which no attempt is made for days or even weeks to determine the nature of the causative organism. Even when time-honored methods of treatment fail to obtain results, hit or miss, or trial and error measures of one kind or another are instituted without avail, with a prolongation of illness, and suffering, and progressive destruction of tissue, often resulting in the death of a patient from a condition which might have been specifically treated had the proper bacteriologic studies been made in the earlier stages of the treatment.

The anaerobic organisms are the ones most neglected; so much so that their ready and accurate cultivation may be considered the criterion of adequate bacteriologic service. Many hospitals do not realize that anaerobic studies of the bacterial flora are always indicated in serious street accidents where the skin is broken, especially in compound fractures, likewise in all infections due to the bites of human beings or animals. All the way along the respiratory and alimentary tracts, the anaerobic organisms play an important role; in ulcerative lesions of the mouth extending directly into the tissues of the neck, or into the lymph glands; following injuries to or operative procedures upon the esophagus; after perforations of the gastrointestinal tract, especially of the lower ileum, appendix, and large bowel, resulting in general peritonitis or peritoneal abscesses; as well as in infections about the rectum and anus. These are all lesions in which the anaerobic organisms thrive. In lung abscess, bronchiectasis, and empyema the anaerobes must be kept in mind. Similarly, all gangrenous processes of the skin, particularly of the extremities, due either to the primary introduction of gangrene-producing organisms or to the interference with blood supply with secondary contamination, are fertile fields for the development of these bacteria. It is obvious, therefore, that in any general hospital the bacteriologic service should be called upon frequently for the determination of the presence of anaerobic as well as aerobic organisms. During the past year in one of the New York hospitals where the importance of this is understood, the anaerobic cultures from a surgical service of approximately 200 beds averaged more than two a day.

Realizing that many hospitals were failing to give their surgical staffs complete bacteriologic service, a year ago we sent a questionnaire to all the hospitals in New York City requesting information specifically with regard to their facilities for making anaerobic cultures, and we also asked the bacteriologist connected with the institution how often he was requested by members of the surgical staff to make anaerobic cultures. These blanks were sent out to 137 hospitals and replies came back from 76. One may assume that most of the others were not particularly interested in the subject and that little if any anaerobic bacteriology is done in most of them. Naturally no attempt was made to inquire into the methods in great detail, and the replies of the bacteriologists in charge are taken at their face value and judged accordingly.

Present methods for determining the sodium concentration in body fluids are not clinically practical. They are laborious and so time-consuming that the clinician cannot afford to wait for these determinations before formulating a program of therapy. Some indication of the sodium concentration of the plasma can be obtained from a measurement of the plasma carbon dioxide combining power. This determination indicates the amount of fixed base in excess of strong acid, or, for all practical purposes, the amount of sodium which is not balanced by chloride ions. Thus, if the body retains sodium in excess of chloride, the plasma carbon dioxide combining power will be high and a condition of alkalosis will result. On the other hand, if sodium is retained to a lesser extent than chloride, the carbon dioxide combining power will be low and inorganic acidosis will be present. Nevertheless, it must be realized that the carbon dioxide combining power is an index only of the relative concentrations of the sodium and chloride ions, and even in alkalosis a significant amount of the body sodium may have been lost. As will be pointed out later, correction of altered chloride concentration with sodium chloride will almost invariably also correct sodium deficiency and acid-base imbalance, and hence concern over correction of alkalosis or inorganic acidosis should almost always be secondary to correction of chloride depletion.

In this paper, for the practical reasons already mentioned, chloride values will be expressed in terms of sodium chloride, and for convenience the term "salt" will be used synonymously with sodium chloride.

METABOLISM OF SODIUM CHLORIDE

In order to appreciate fully the problems frequently encountered by the surgeon in sodium chloride administration, a brief discussion of salt metabolism is necessary.

Functions of Sodium Chloride.—Sodium chloride, the most abundant electrolyte in the body fluids, serves two vital functions. In the first place, it helps to maintain the acid-base balance of the body. One has only to note the variations in composition of different body fluids (Fig. 1)¹ to appreciate the intricacies involved in the maintenance of this balance and the important parts played by the sodium and chloride ions in the body chemistry. Secondly, sodium chloride, through its influence on osmotic pressure, helps to regulate the amount and distribution of body water. The total amount of water that the body can retain and the distribution of that water depends largely upon the total electrolyte composition of the body fluids. Gamble and Ross² have pointed out that when the chloride ion is lost from the body it is readily replaced by the bicarbonate ion which is formed from carbon dioxide. Thus, the total electrolyte content of the body remains the same and there is no significant change in the amount of body water. However,

when sodium is lost, no other ion can adequately take its place, and, in order to maintain the acid-base balance of the body, bicarbonate and chloride ions are excreted. Thus, there is a definite depletion of the total electrolyte content of the body, which in turn leads to a decrease in the total body water. This indicates that the loss of sodium ions is the essential factor in the dehydration so commonly associated with loss of gastrointestinal secretions. From these brief considerations the importance of sodium chloride in the body is apparent.

Distribution and Concentration of Sodium Chloride.—Sodium chloride is widely and fairly uniformly distributed throughout the extracellular body fluids. About 25 per cent of the body sodium is fixed in the skeleton,³ whereas, most studies indicate that all of the chlorine exists in

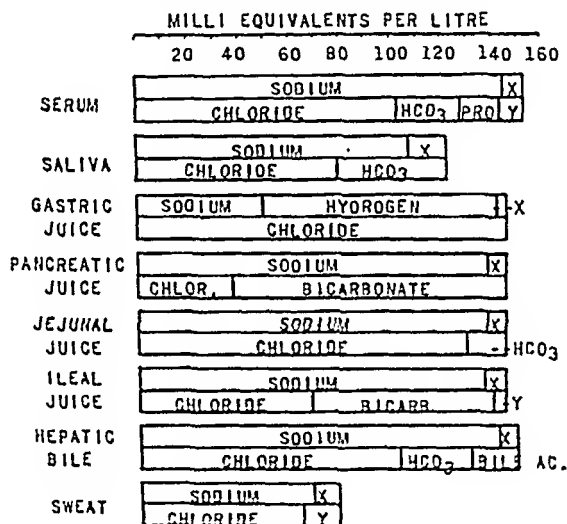


Fig. 1.—Composition of body fluids (after McCance¹). X, Un-named basic radicals; Y, un-named acidic radicals.

ionic form.^{4,5} Thus the great bulk of the sodium chloride is dissolved in the extracellular fluids. Normally, the chloride concentration in the blood plasma ranges from 560 to 630 mg. sodium chloride per 100 c.c.⁴ Lymph, serous fluids,⁴ and cerebrospinal fluid⁶ contain a slightly higher concentration of chlorides, the additional salt being necessary to counter-balance the osmotic pressure of the proteins in the blood plasma.

Total Salt Content of the Body.—The total salt content of the human body has been estimated in various ways by a number of workers. These estimates are tabulated in Table I. Because the figure given by Sherman¹³ has fitted in so well with the experimental work which will be presented later in this paper, we have assumed that it must be reasonably accurate and have adopted it in our calculations. Sherman states that the chlorine content of the body is 0.15 per cent of the body weight.

Expressed in terms of sodium chloride, this amounts to 0.248 per cent of the body weight, or 148.8 gm. of sodium chloride in a 60 kg. individual.

Salt Balance.—The sodium chloride content of the body is maintained at a normal level under ordinary conditions by the dietary intake and

TABLE I
TOTAL SALT CONTENT OF THE BODY

| AUTHORITY | ACTUAL STATEMENT OF AUTHORITY | CALCULATED SODIUM CHLORIDE CONTENT OF 60 KG. MAN (GM.) |
|----------------------------------|---|--|
| Magnus-Levy ⁹ | Chlorine = 0.1227% of body weight | 121.7 |
| Lotka ¹⁰ | Chlorine = 0.16% of body weight | 158.4 |
| White and Bridge ¹¹ | The dog contains about 2.5 gm. of salt per kg. of body weight | 150.0 |
| Falconer and Lyall ¹² | The total chloride content of the body is about 90 gm. | 90.0 |
| Sherman ¹³ | Chlorine = 0.15% of body weight | 148.8 |

the efficient regulatory mechanism of the kidneys. The salt content of the diet varies with the taste of the individual, the average person ingesting about 8 to 12 gm. of sodium chloride per day. Of this about 2 per cent,¹⁴ or 0.2 gm., is excreted normally in the feces and if sweating does not occur from 0.24 to 0.41 gm. (0.15 to 0.25 gm. of chlorine)¹⁵ is lost through the skin. Thus, about 0.5 gm. of salt is lost through these two channels daily and the remainder of the salt intake, after being used for acid-base balance adjustments and for the maintenance of optimal body fluid volume, is excreted in the urine. If larger amounts of salt are excreted in diarrheal stools, sweat, or by vomiting, the salt content of the urine is correspondingly decreased. It is obvious that the salt intake must balance the salt output or else the body chemistry will be disturbed. In order to compensate for salt losses through the skin and feces and to facilitate acid-base adjustments and the maintenance of body fluid volume, we believe that the daily intake of salt should normally be about 5 to 10 gm.

Excessive Salt Intake.—If sodium chloride is ingested in large amounts, the body will dispose of it in one of two ways. (1) Usually the excess salt will be excreted promptly in the urine, provided that sufficient water is available for its excretion. The maximum concentration at which the kidneys can excrete salt is in a 2 per cent solution.⁴ (2) In many sick patients much of the excess salt will be retained with water in the interstitial spaces in a concentration equal to that normally found in interstitial fluid and the individual may develop edema. These facts are illustrated in Tables II and III. Table II shows the metabolism of excessive amounts of salt in a 17-year-old male late in his convalescence from peritonitis. He had been on a general diet for a number of days prior to the beginning of this study and was excreting normal amounts

TABLE II

METABOLISM OF EXCESSIVE AMOUNTS OF SALT IN A 17-YEAR-OLD MALE SUBJECT*

| 24 HR. OF STUDY | BODY WEIGHT KG. | NaCl INTAKE | | | NaCl IN URINE GM. | PLASMA CHLORIDE MG. NaCl/ 100 C.C. | PLASMA CO ₂ COM- BINING POWER % |
|-----------------------|-----------------------|-------------|-----------------------------|--------------|-------------------------|---|---|
| | | DIET GM. | RINGER'S SOL. IV. GM. | TOTAL GM. | | | |
| | 50.52 | -- | -- | -- | -- | 545 | 52.0 |
| 1 | 50.64 | 3.3 | 28.6 | 31.9 | 21.1 | 548 | 57.1 |
| 2 | 50.46 | 2.2 | 0.0 | 2.2 | 9.2 | 543 | 55.2 |
| Totals | | 5.5 | 28.6 | 34.1 | 30.3 | | |

*Note the prompt excretion of salt in the urine and the insignificant variations in plasma chlorides in spite of the administration of large amounts of sodium chloride.

of salt in the urine. At the beginning of the study the patient was weighed and his plasma chlorides and carbon dioxide combining power were determined. He was then given a diet of known salt content and 3,200 c.c. of Ringer's solution containing 28.6 gm. of sodium chloride intravenously at the rate of 500 c.c. per hour. The next day the only salt ingested was a small amount in the diet. It will be noted that practically all of the salt given was soon excreted in the urine.

TABLE III

METABOLISM OF EXCESSIVE AMOUNTS OF SODIUM CHLORIDE IN SERIOUSLY ILL PATIENTS*

| PATIENT | DAYS OF STUDY | TOTAL NaCl GIVEN GM. | NaCl EXCRETED IN URINE GM. | NaCl RETAINED GM. | INITIAL PLASMA CHLORIDES MG. % | HIGHEST PLASMA CHLORIDES MG. % | GAIN IN WEIGHT KG. |
|---------|------------------|-------------------------------|-------------------------------------|-------------------------|---|---|-----------------------------|
| A. W. | 4 | 111.3 | 56.3 | 55.0 | 532 | 506 | 4.4 |
| W. F. | 4 | 101.8 | 65.1 | 36.7 | 480 | 597 | 0.6 |
| P. G. | 4 | 115.1 | 80.8 | 34.3 | 553 | 640 | 1.8 |
| W. H. | 2 | 51.5 | 22.6 | 28.9 | 554 | 604 | 3.1 |

*Note the tendency to gain in weight following the administration of large amounts of saline solution and also that the plasma chloride level does not rise above normal in spite of the large amounts of sodium chloride given.

Table III shows the metabolism of large quantities of salt in four seriously ill patients.¹⁶ The salt was given intravenously in isotonic solution over periods of two to four days. All of the patients gained in weight, although the daily caloric intake in each instance was far below the actual energy requirements of the patients. This gain in weight was due to the retention of salt and water, resulting in the formation of sub-clinical edema.

The data in Tables II and III also illustrate another practical point about the metabolism of excessive amounts of salt. In Table II it is noted that the plasma chloride level did not change significantly in spite of the large salt intake. In Table III it will be seen that the plasma chloride level rose above the upper limits of normal in only one instance (P. G.); whereas, in Patient A. W. it actually decreased in spite of the excessive salt intake. In sickness, for reasons not yet wholly understood, the plasma chloride level often drops and frequently cannot be

raised above the lower limits of normal. In some cases even such a level cannot be maintained. This is also well illustrated by the data presented in Table IV. This patient was in poor condition two days after a partial

TABLE IV
METABOLISM OF EXCESSIVE AMOUNTS OF SALT IN A SERIOUSLY ILL PATIENT*

| 24 HOURS ENDING | BODY WEIGHT KG. | NACL GIVEN GM. | NACL LOST | | | NACL RETAINED GM. | PLASMA CHLORIDES MG. NACL/100 C.C. |
|--------------------|-----------------------|----------------------|---|--------------|--------------|-------------------------|--|
| | | | GASTROIN- TESTINAL TRACT DRAINAGE GM. | URINE GM. | TOTAL GM. | | |
| 4/20/38 | -- | -- | -- | -- | -- | -- | 352 |
| 4/21/38 | 45.30 | 61.5 | 4.8 | 10.9 | 15.7 | +45.8 | 510 |
| 4/22/38 | 43.74 | 0 | 3.7 | 12.5 | 16.2 | +29.6 | 492 |
| 4/23/38 | 41.06 | 35.5 | 4.8 | 14.3 | 19.1 | +16.0 | 512 |

*Note that the plasma chlorides in this sick patient fail to reach the lower limits of normal in spite of the excessive administration of sodium chloride.

gastrectomy for carcinoma of the stomach, and his plasma chlorides were found to be 352 mg. sodium chloride per cent. He was given 61.5 gm. of sodium chloride intravenously in the form of physiologic salt solution. As will be shown later, this in his case is far more than sufficient salt to raise the plasma chlorides to 560 mg. per cent, yet his plasma chlorides rose only to 510 mg. per cent. Two days later he was again given an excessive amount of salt, but his plasma chlorides failed to rise above 512 mg. per cent. Thus, this sick individual was unable to attain a normal plasma chloride level in spite of excessive salt administration. These observations have an important clinical application in that they show clearly that the plasma chloride level cannot be used as an index of excessive salt administration. DeWesselow¹⁷ made the same observation a number of years ago stating: "Balance experiments have demonstrated that chloride retention involves water retention, and that approximately a litre of water is retained for every 6 to 7 grams of sodium chloride that accumulate in the body, a normal concentration of about 0.6 per cent of sodium chloride being thus preserved in the body fluids and plasma. The result of salt retention is therefore hydraemia, rather than hyperchloraemia."

Although healthy animals will tolerate tremendous amounts of physiologic saline solution,^{18, 19} the grave dangers of excessive salt administration to sick patients have been recognized by a number of workers.^{17, 20-21} Not only is there danger of death from pulmonary edema, but edema may also be responsible for delayed healing of wounds. Thus, for the welfare of the patient, it is important that excessive amounts of sodium chloride should not be given.

Deficient Salt Intake.—If the intake of sodium chloride is suddenly stopped, significant amounts of salt will continue to be excreted in the

urine for several days. Benedict²⁵ followed the urinary excretion of chlorine in a subject fasting for thirty-one days. During this period, 20.3 gm. of sodium chloride (12.3 gm. of chlorine) were excreted in the urine. However, half of this amount was lost during the first four days. We studied four healthy individuals in this regard and found that they excreted from 3.0 to 16.7 gm. of salt in the urine during the first four days they were on a salt-poor diet. Throughout this period there was no significant alteration in the plasma chloride concentration (see Table VI and Fig. 2). It was suggested by Benedict that most of this initial salt lost was withdrawn from the skin. Because of the marked solubility of sodium chloride and because of the relatively small

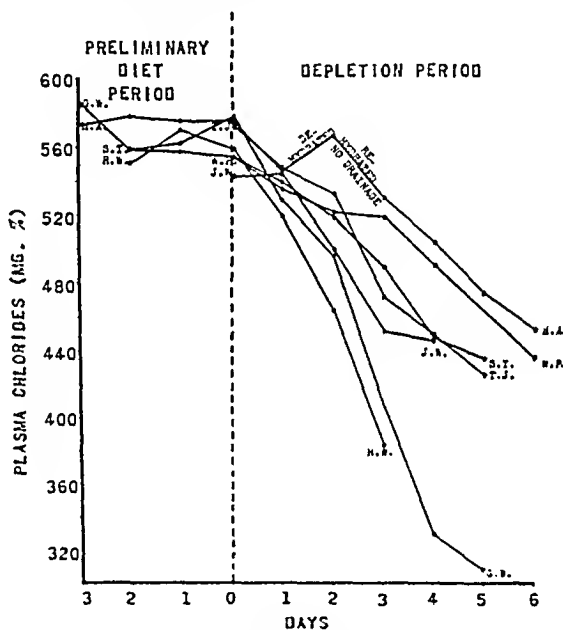


Fig. 2.—Production of hypochloremia in humans by withdrawal of gastrointestinal secretions.

amount of chloride lost in the urine during prolonged fasting, it is very doubtful that an excess of salt is stored in the body.^{25, 26}

After a few days of deficient salt intake, the kidneys show remarkable ability in conserving the salt remaining in the body, the urinary excretion falling to much less than 0.5 gm. per day. If, in addition, the body loses salt by some abnormal route and the plasma chlorides fall below normal, the salt content of the urine almost invariably becomes less than 100 mg. per day. This protection of the electrolyte content of the body by the kidneys has been observed by many workers.^{11, 25, 28}

Abnormal Salt Losses.—Salt may be lost from the body in considerable quantities through various channels including (1) the upper gastrointestinal tract, (2) the lower gastrointestinal tract, (3) the skin, and (4) drainage from wounds.

raised above the lower limits of normal. In some cases even such a level cannot be maintained. This is also well illustrated by the data presented in Table IV. This patient was in poor condition two days after a partial

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|--------------------|-----------------------|----------------------|---|--------------|--------------|-------------------------|--|
| | | | GASTROIN- TESTINAL TRACT DRAINAGE GM. | URINE GM. | TOTAL GM. | NACL RETAINED GM. | |
| 4/20/38 | -- | -- | -- | -- | -- | -- | 352 |
| 4/21/38 | 45.30 | 61.5 | 4.8 | 10.9 | 15.7 | +45.8 | 510 |
| 4/22/38 | 43.74 | 0 | 3.7 | 12.5 | 16.2 | +29.6 | 492 |
| 4/23/38 | 44.06 | 35.5 | 4.8 | 14.3 | 19.1 | +46.0 | 512 |

*Note that the plasma chlorides in this sick patient fail to reach the lower limits of normal in spite of the excessive administration of sodium chloride.

gastrectomy for carcinoma of the stomach, and his plasma chlorides were found to be 352 mg. sodium chloride per cent. He was given 61.5 gm. of sodium chloride intravenously in the form of physiologic salt solution. As will be shown later, this in his case is far more than sufficient salt to raise the plasma chlorides to 560 mg. per cent, yet his plasma chlorides rose only to 510 mg. per cent. Two days later he was again given an excessive amount of salt, but his plasma chlorides failed to rise above 512 mg. per cent. Thus, this sick individual was unable to attain a normal plasma chloride level in spite of excessive salt administration. These observations have an important clinical application in that they show clearly that the plasma chloride level cannot be used as an index of excessive salt administration. DeWesselow¹⁷ made the same observation a number of years ago stating: "Balance experiments have demonstrated that chloride retention involves water retention, and that approximately a litre of water is retained for every 6 to 7 grams of sodium chloride that accumulate in the body, a normal concentration of about 0.6 per cent of sodium chloride being thus preserved in the body fluids and plasma. The result of salt retention is therefore hydraemia, rather than hyperchloraemia."

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No accurate figures are available for the salt content of the exudates from wounds, but it is reasonable to assume that these will also contain significant amounts of sodium chloride. Undoubtedly, accompanying the massive exudation of large burned surfaces, there must be a considerable loss of body electrolytes.^{41, 42}

In summary, it will be noted that the salt concentration of these various secretions the loss of which will lead to depletion of the body chlorides is in general about the same as the salt concentration of blood plasma; that is, about 5 to 6 gm. per liter. It is worthwhile emphasizing at this point that salt is always lost abnormally from the body in the form of an isotonic or hypotonic fluid, and therefore when replacing this salt sufficient water must also be given to make it at least isotonic. The body never loses salt without water, and water must be available to the body if it is to retain the salt that it needs.

CLINICAL ASPECTS OF LOSS OF BODY CHLORIDES—HYPOCHLOREMIA

Modes of Depletion.—Any condition associated with the loss of one or more of the previously mentioned secretions will lead to the depletion of the body chlorides with its resulting dangers. Among such conditions may be listed: pyloric and intestinal obstruction, acute poisoning, peritonitis, paralytic ileus, hyperemesis gravidarum, and postanesthetic nausea, all of these leading to vomiting or to the use of gastroduodenal suction; choledochostomy; enterostomy and fecal fistulas; ulcerative colitis, amoebic and bacillary dysentery, neoplasm of the large bowel and rectum, and similar diseases in which diarrhea is a prominent feature; and high fever and other conditions in which sweating is profuse. These conditions are so commonly encountered by the surgeon, and often by the internist and pediatrician, that it is obvious that he must frequently deal with the problem of chloride replacement.

Summary of Literature.—A tremendous amount of work has been done in recent years to establish the following significant facts: (1) Salt may be lost from the body, as already indicated, in the form of upper gastrointestinal secretions, diarrhea, sweat, and wound drainage.^{2, 11, 17, 27-43, 48, 49, 51, 52, 54-57, 59, 66, 84, 86-88, 90-92, 94-96, 98-100} (2) Loss of salt in such ways results in lowering of the plasma chlorides, often in disturbances of acid-base balance, and frequently in elevation of the blood nonprotein nitrogen (azotemia).^{2, 11, 17, 27, 28, 33, 40-42, 45-48, 50, 52-62, 64, 68-81, 84, 88, 89, 91, 93-101} (3) Lowering of the plasma chlorides is accompanied by a fall in the salt concentration in the other body fluids and tissues.^{11, 27, 28, 49, 74, 81} (4) Depletion of the body salt in itself results in definite morbidity and often in death.^{2, 11, 27, 28, 31, 39, 40, 43, 45, 48, 50, 52, 54, 56, 57, 59, 81, 86, 87, 96, 99, 100} (5) The administration of saline solution is often a life-saving measure under such circumstances.^{11, 23, 31, 42-45, 49, 53-56, 58, 59, 61, 63, 66, 67, 71-73, 75-77, 79-83, 85-88, 90-92, 94, 97, 99, 100} (6) The administration of electrolytes other than sodium chloride is not effective.^{2, 45, 65, 71, 85}

Salt may be lost from the upper gastrointestinal tract in vomitus, gastroduodenal drainage, or the drainage from duodenal, pancreatic, biliary, or intestinal fistulas. The salt content of these secretions as they are encountered clinically is indicated in Table V. It will be noted

TABLE V
WAYS IN WHICH SALT MAY BE LOST FROM THE BODY

| SECRETION | RANGE OF NaCl CON- CENTRATION GM./L. | AVERAGE NaCl CON- CENTRATION GM./L. | SOURCES OF INFORMATION |
|--|---|--|---|
| Vomitus | 1.2-6.2 | 3.3 | Dick, Coller, and Maddock ²⁹ |
| Gastroduodenal drainage (Wan- gensteen suc- tion) | 1.9-7.9 | 5.7 | Analysis of 100 24-hour undi- luted specimens |
| Hepatic bile | 3.5-6.4 | 5.1 | Analysis of 30 24-hour speci- mens |
| Intestinal fistulous drainage | 3.1-6.6 4.7-7.9 3.0-8.8 | 5.2 | Analysis of 2 specimens: Welch et al. ¹⁴ Karr and Abbott ³⁰ |
| Diarrheal stools | 3.7-5.2 | 4.3 | Analysis of 3 specimens |
| Sweat | 3.4-7.8 1.2-4.6 4.3-8.3 1.2-3.3 | 4.7 | Cameron ³⁵ Dill, et al. ³⁶ Talbert and Haugen ³⁷ Moss ³⁸ |

that the salt content of gastroduodenal drainage is considerably higher than that of vomitus. This is due to the fact that some of the specimens of vomitus examined were diluted by water that had been drunk shortly before the emesis occurred; whereas, none of the specimens of gastroduodenal drainage was thus diluted.

As mentioned previously, normal feces contain an insignificant amount of salt.^{4, 14} Large amounts of sodium chloride may be lost, however, through the lower portion of the gastrointestinal tract when diarrhea or profuse rectal discharge is present. The significant salt losses in the stools of cholera patients were recognized over one hundred years ago.³¹ The electrolyte losses in the diarrheal stools of infants and in patients with ulcerative colitis have also been found to be abnormally large.^{32, 33}

Salt losses through the skin are very slight if perspiration is avoided,^{15, 34} but when the sweat glands are called into action, either in high fever or in exertion at high temperatures or high humidities, the salt losses through the skin become very important.³⁵⁻³⁸ McCance^{39, 40} was able to produce salt deficiency in humans merely by causing them to sweat profusely. Various determinations of the salt concentration of sweat have been made, the more outstanding ones being summarized in Table V.

TABLE VI—CONT'D

| H. A. | 1/19/38 | 2,475 | --- | --- | 10,765 | --- | 10,765 | 573 | 53.8 |
|-------|----------|--------|--------|-------|--------|--------|--------|--------|------|
| • { | 1/20/38 | 1,630 | --- | --- | 3,048 | --- | 2,100 | 576 | --- |
| | 1/21/38 | 1,810 | --- | --- | 2,100 | --- | 0,766 | 578 | --- |
| | 1/22/38 | 1,320 | --- | --- | 0,766 | --- | --- | --- | 55.8 |
| | Total | 360 | 2,010 | 2,010 | 16,679 | --- | 16,679 | --- | --- |
| J. W. | 1/23/38 | 72.37 | 0 | 2,010 | 2,010 | --- | 6,613 | 546 | 51.7 |
| | 1/24/38 | 70.01 | 822 | 930 | 1,722 | 0,646 | 3,015 | 568 | 53.1 |
| | 1/25/38 | 72.73 | 3,560 | --- | 3,560 | 0,046 | --- | 531 | 56.3 |
| | 1/26/38 | 70.05 | 4,612 | 2,310 | 5,315 | 0,270 | 10,511 | 505 | 49.2 |
| | 1/27/38 | 70.39 | 5,151 | 1,640 | 3,950 | Nil | 7,938 | 475 | 49.5 |
| | 1/28/38 | 70.05 | 4,571 | 1,510 | 3,250 | 0,122 | 6,448 | 454 | --- |
| | Total | 15,955 | 11,437 | 8,370 | 19,897 | 17,766 | 34,525 | 52,291 | --- |
| | 59.8 | --- | --- | --- | --- | --- | --- | 543 | 51.3 |
| T. J. | 10/ 7/37 | 4,000 | 1,530 | 650 | --- | --- | --- | 574 | 51.0 |
| | 10/ 8/37 | 4,000 | 3,000 | 1,210 | 2,180 | 5.78 | 3.38 | 548 | 49.1 |
| | 10/ 9/37 | 4,000 | 865 | 1,625 | 4,210 | 1.74 | 8.19 | 533 | 50.7 |
| | 10/10/37 | 4,000 | 1,515 | 150 | 2,490 | 0.01 | 11.59 | 472 | 61.1 |
| | 10/11/37 | 4,000 | 3,130 | 885 | 1,665 | 0.05 | 0.10 | 450 | 61.4 |
| W. P. | 10/12/37 | 4,000 | 10,040 | 4,520 | 4,015 | 0.13 | 5.30 | 427 | 59.9 |
| | Total | 20,000 | 17,510 | 3,820 | 14,560 | 7.71 | 28.56 | 36.26 | --- |
| | 67.7 | --- | --- | --- | --- | --- | --- | 556 | 51.5 |
| | 10/29/37 | 4,500 | 1,330 | 540 | 1,870 | 2.55 | 2.63 | 536 | 51.5 |
| | 10/30/37 | 4,000 | 5,020 | 360 | 5,980 | 4.10 | 1.97 | 523 | 55.0 |
| --- | 10/31/37 | 4,000 | 3,740 | 770 | 4,510 | 2.02 | 3.80 | 520 | 56.7 |
| | 11/ 1/37 | 4,000 | 2,530 | 575 | 3,105 | 0.20 | 3.62 | 492 | 57.6 |
| | 11/ 2/37 | 4,000 | 2,040 | 600 | 2,640 | 0.16 | 3.74 | --- | --- |
| | 11/ 3/37 | 4,000 | 2,550 | 975 | 3,525 | 0.05 | 5.44 | 436 | 57.3 |
| --- | 11/ 4/37 | 4,000 | --- | --- | --- | --- | --- | --- | --- |
| | Total | 24,500 | 17,510 | 3,820 | 21,650 | 9.08 | 21.20 | 30.28 | --- |

TABLE VI
PRODUCTION OF HYPOCHOLEMIA IN HUMANS BY WITHDRAWAL OF GASTROINTESTINAL SECRETIONS

| PATIENT | 24 HR. Fasting | BODY WEIGHT KG. | FLUID IN- | | FLUID OUTPUT | | | CHLORIDE LOSSES (AS NaCl) | | | PLASMA CHLORIDES MG. NaCl/ 100 C.C. | PLASMA CO ₂ COM- BINING POWER VOL. % |
|---------|------------------------------------|-----------------------|---|---------------|--|---------------|--------------|---|--------------|--------|--|---|
| | | | TAKE (5% GLUCOSE IN DISTILLED WATER I. V.) C.C. | URINE C.C. | GASTRO- INTESTINAL TRACT DRAINAGE C.C. | TOTAL C.C. | URINE GM. | GASTRO- INTESTINAL TRACT DRAINAGE GM. | TOTAL GM. | | | |
| R. W. | { 11/28/37 11/29/37 11/30/37 | 56.60 | --- | 2,665 | --- | --- | 2,025 | --- | 2,025 | 551 | 43.7 | |
| | | 57.13 | --- | 940 | --- | --- | 0.636 | --- | 0.636 | 571 | 46.8 | |
| | | 56.95 | --- | 2,390 | --- | --- | 0.359 | --- | 0.359 | 559 | 47.1 | |
| | Total | | 2,990 | 2,660 | 3,015 | 5,275 | 0.497 | 12,995 | 13,492 | 520 | 52.7 | |
| | Total | | 4,280 | 1,240 | 3,920 | 3,920 | 0.074 | 10,800 | 10,874 | 464 | 71.2 | |
| S. T. | { 12/11/37 12/12/37 12/13/37 | 72.43 | --- | 1,330 | --- | --- | 3,742 | --- | 3,742 | 33.913 | 37.655 | |
| | | 72.42 | --- | 990 | --- | --- | 0.878 | --- | 0.878 | 559 | 51.6 | |
| | | 72.58 | --- | 1,295 | --- | --- | 1.030 | --- | 1.030 | 558 | 55.3 | |
| | Total | | 4,730 | 3,225 | 3,225 | 3,225 | 0.090 | 6,324 | 6,414 | 449 | 63.2 | |
| | Total | | 11,040 | 4,340 | 7,675 | 12,015 | 0.152 | 4,188 | 4,340 | 436 | 67.3 | |
| G. W. | { 1/ 4/38 1/ 5/38 1/ 6/38 | 75.39 | --- | 9,990 | 8,745 | 18,735 | 3,214 | 31,993 | 35,207 | 586 | --- | |
| | | 74.61 | --- | 1,815 | --- | --- | 4,990 | --- | 4,990 | 559 | --- | |
| | | 72.75 | --- | 1,620 | --- | --- | 0.842 | --- | 0.842 | 563 | --- | |
| | { 1/ 7/38 1/ 8/38 | 71.53 | --- | 1,860 | --- | --- | 0.781 | --- | 0.781 | 579 | 51.0 | |
| | | Total | | 3,201 | 1,810 | 2,760 | 4,570 | 0.561 | 14,794 | 15,255 | 530 | --- |
| G. W. | { 1/ 9/38 1/10/38 1/11/38 | 66.76 | 240 | --- | 2,820 | 2,820 | --- | 13,592 | 13,592 | 497 | --- | |
| | | 67.14 | 4,464 | 355 | 2,175 | 2,530 | 0.046 | 11,006 | 11,052 | 408 | --- | |
| | | 67.06 | 4,094 | 120 | 1,980 | 2,100 | 0.012 | 8,989 | 9,001 | 330 | 56.1 | |
| | { 1/12/38 1/13/38 | --- | 2,414 | 810 | 0 | 810 | 0.105 | 0 | 0.105 | 308 | 53.9 | |
| | | Total | | 15,413 | 3,095 | 9,735 | 12,830 | 9.648 | 48,381 | 58,029 | --- | --- |

*Preliminary feeding on salt-poor diet of normal subject.

* Preliminary period on salt-poor diet of normal subject.

in the gastrointestinal secretions remained fairly constant, even when the plasma chlorides were far below normal. This has also been noted by others,⁹⁹ although it has been pointed out that in the gastric secretion the amount of free acid rapidly decreases. At the conclusion of the experiments the subjects were given sufficient salt to restore the body chlorides to normal. This will be discussed later under the treatment of hypochloremia.

Restating the vast amount of work that has been done on the chemical adjustments resulting from loss of body salt, we feel that one may draw the following conclusions. The loss of body secretions containing salt results first in a fall in the plasma chlorides (hypochloremia) and in a depletion of the body chlorides in general. Soon afterward there is often an alteration in the acid-base balance and finally there is commonly a rise in the blood nonprotein nitrogen.

Chloride Loss in Excess of Sodium.—If chloride ions are lost with little loss of sodium ions, the loss of chloride ions is compensated for by an increase in bicarbonate ions. This keeps the total electrolyte composition of the body constant, and hence, if sufficient water is available, there will be little change in the total water content of the body. However, the altered proportion of sodium and chloride ions will result in alkalosis and will be indicated by a high plasma carbon dioxide combining power. If sufficient water is not available, dehydration will result; the kidneys will not have sufficient water to excrete the nitrogenous waste products, and the nonprotein nitrogen of the blood will rise. Giving water to such a patient will restore the nonprotein nitrogen to normal but will not correct the alkalosis, chloride ions being necessary for this adjustment.

Equal Loss of Chloride and Sodium.—If sodium and chloride ions are lost in equal proportions, there will be no disturbance of the acid-base balance. However, the electrolyte content of the body will be decreased and hence body water will be eliminated in an effort to keep the sodium concentration and the osmotic pressure of the body fluids constant. With this loss of body fluid, dehydration will result and nitrogenous waste products will be retained. If sodium, and with it water, continues to be lost, a certain point apparently is reached where the retention of water becomes more important to the body than the maintenance of a normal sodium concentration. In order to retain the water, we believe the body retains the nonelectrolyte urea which, being osmotically effective, leads to the partial protection of body fluid volume which has been depleted by the loss of sodium. The blood nonprotein nitrogen will rise and the administration of water in such an instance will not lower it significantly, sodium chloride being necessary as well.

Sodium Loss in Excess of Chloride.—If sodium is lost in excess of chloride ions, acidosis and a decrease in bicarbonate ions will result. There will be a loss of body fluids and an increase in the blood non-

Excellent reviews of salt metabolism with extensive bibliographies have recently been published by Kerpel-Fronius¹⁰² and McCance.^{1, 26, 40}

Experimental Hypochloremia.—In spite of these extensive investigations, however, surprisingly little quantitative work has been done in humans.^{39, 40} For this reason we conducted a series of experiments on human subjects in order to correlate gastrointestinal tract losses with changes in the plasma chloride concentration. Four of the subjects (R. W., S. T., G. W., and H. A.) (Table VI and Fig. 2) were healthy individuals. The others (J. W., T. J., and W. P.) were surgical patients. The subjects were studied in the following manner. Each healthy individual was placed on a salt-poor diet and the body weight, plasma chlorides, plasma carbon dioxide combining power, and urinary chlorides were determined each day.* When the daily salt excretion in the urine became less than 1 gm., the subject was put to bed, a Levine tube was passed through the nose into the stomach, and gastrointestinal secretions were aspirated continuously by means of a Wangenstein type of suction.¹⁰⁰ A trap bottle was placed in the system in order to collect all of the gastrointestinal drainage. The Levine tube was irrigated regularly with air. This kept the tube open, but did not dilute the drainage as water would have done. The subject was allowed nothing by mouth except salt-free hard candy. The daily water needs were provided for by giving 5 per cent glucose in distilled water intravenously. The surgical patients were cases in which gastroduodenal suction was indicated because of their condition. They were studied in a manner similar to the normal subjects except that they were not weighed daily nor were they initially placed on a salt-poor diet, the study being started immediately after their operations. None of the subjects had stools during the period of gastroduodenal drainage. Salt losses through the skin were not determined, but in no case was there profuse sweating.

The data obtained from these studies are presented in Table VI, and the variations in the plasma chlorides are shown graphically in Fig. 2. During the period on the salt-poor diet, the plasma chloride concentration remained practically constant, but accompanying the withdrawal of chlorides in the gastrointestinal secretions the concentration of the plasma chlorides fell promptly and progressively to significantly low values. Thus, in humans as well as in animals loss of gastrointestinal secretions results in a decrease in the plasma chloride level and the figures presented in Table VI give some indication of the quantitative relationship between the total chloride lost and the resulting plasma chloride level. It is interesting to note that the concentration of salt

*In all of our studies plasma chlorides were determined by the Wilson and Ball¹⁰⁴ modification of the Van Slyke technique, except that the blood was not collected under oil. Determinations, however, were made promptly after the collection of specimens. Urinary chlorides and the chlorides of gastrointestinal secretions were determined by the Volhard-Arnold method,¹⁰⁶ the specimens being first decolorized with potassium permanganate. The carbon dioxide combining power was measured by the method described by Hawk and Bergelm¹⁰⁵ except that the specimens were not collected under oil.

majority of patients if the plasma chlorides fall to 450 mg. per cent. However, more important than a knowledge of the plasma chloride level at which symptoms develop is the realization of the fact that even in patients with plasma chlorides between 560 and 500 mg. per cent there has been a definite loss of electrolytes and water from the body and this deficit ought to be corrected by the administration of saline solution if the chemical processes of the body are to be carried on most effectively.

Diagnosis of Hypochloremia.—The finding of a low plasma chloride concentration establishes the diagnosis of hypochloremia. However, this condition should always be kept in mind in any patient who is losing fluids abnormally, and it should be strongly suspected when any of the above symptoms or signs are present. Too much emphasis cannot be placed upon the importance of studying the body chemistry of patients with major surgical diseases. This is especially true of the preoperative preparation of patients. Others^{77, 91, 99} have stressed the value of a rough estimation of the urinary chlorides by the simple silver nitrate precipitation test. If a low salt content of the urine is found, more extensive chemistry studies are indicated. At present we are working on an improved test for quick determination of urinary chlorides and hope that it will prove to be of value in anticipating cases of salt deficiency.

Prevention of Hypochloremia.—Hartwell and Hoguet⁴⁴ and many of the other early workers found that death from depletion of the body chlorides in experimental animals could be prevented by the administration of sufficient quantities of physiologic saline solution. Diek, Maddock, and Coller²⁹ have pointed out that the concentration of sodium chloride in gastrointestinal secretions is always less than the concentration of sodium chloride in physiologic saline or Ringer's solution. They have suggested that salt deficiency should not develop if one follows the rule of replacing gastrointestinal tract losses with equal volumes of physiologic saline or Ringer's solution. The same suggestion has been made by Nadler.¹⁰⁹

To determine the practicability of this rule, we investigated a series of surgical patients who were losing fluids from the gastrointestinal or biliary tract, or both.* These patients were studied in the following manner: Immediately after operation each patient was weighed on a special scale; a Levine tube was passed into the stomach and continuous suction applied; and a blood specimen was taken for the determination of the plasma chlorides. The patient's water requirements were then provided for by the intravenous administration of 5 per cent glucose in distilled water. On each succeeding morning the patient was weighed, the 24-hour specimens of urine, gastrointestinal, and biliary tract drain-

*An abstract of the following experimental work was read before the American Surgical Association, Atlantic City, N. J., May 2, 1938.¹¹⁰

protein nitrogen. Again water will not be effective in correcting this condition, sodium ions also being needed.

In practically all situations encountered by the surgeon, there is a loss of both sodium and chloride ions, although the relative proportion of the two may vary. In most instances where the loss is from the upper gastrointestinal tract, chlorides are lost in excess of sodium with resulting alkalosis; whereas, if the losses are from the lower intestine, sodium is lost in excess of chlorides and acidosis results. However, the treatment of alkalosis and acidosis is greatly simplified by the fact that the administration of sodium chloride and abundant amounts of water will correct either condition, the kidneys, if they are not diseased, excreting the ion that is given in excess.¹⁰⁷ At the same time the salt depletion of the body is corrected. Depletion of the body salt is accompanied by definite morbidity, and if the plasma chlorides fall to about half their normal value, death results.²⁷

Symptoms and Signs of Hypochloremia.—The symptoms and signs resulting from depletion of the body chlorides are insidious in their onset and are often masked by the more obvious findings of the disease causing the hypochloremia. Frequently the clinician attributes certain symptoms to the disease process when in reality they are due specifically to the altered physiology resulting from the lowered body chlorides. On the basis of our observations and numerous comments in the literature,^{39, 40} we have found the symptoms most constantly encountered in hypochloremia to be: (1) marked lethargy, lassitude, depression, weakness, and fatigue; (2) dulling of the sense of taste, anorexia, and nausea; (3) dulling of the mentality, drowsiness, stupor and coma; and (4) occasionally muscular twitching and cramps. The signs are less constant in their occurrence. Dehydration characterized by a dry tongue, sunken eyes, and dry, inelastic skin is often present. Alkalosis with slow shallow respirations and occasionally tetany may be encountered in cases with pyloric obstruction. Acidosis with rapid deep breathing is not uncommon in cases with severe diarrhea. A low pulse pressure has been reported in some instances. We have seen three patients with hypochloremia presenting the clinical picture of shock, and others have also noted the association of these two findings.¹⁰⁸ It will be noted that these are the signs and symptoms that are frequently encountered in severely ill patients from various causes, and so it is understandable why the clinician often accepts them as part of the symptom complex of the disease itself rather than attributing them to the disturbed body chemistry which is present in certain instances.

The question is frequently asked: How low must the plasma chlorides be before symptoms are produced? Because of the gradual onset and the difficulty in evaluating such early symptoms as lassitude and fatigue, a definite answer to this question can hardly be given. Some patients will show symptoms with plasma chlorides of 500 mg. per cent, and the

TABLE VII
REPLACEMENT OF UPPER GASTROINTESTINAL SECRETION LOSSES WITH EQUAL VOLUMES OF PHYSIOLOGIC SALINE SOLUTION
(1 L. \approx 8.5 GM. OF SODIUM CHLORIDE)

| PATIENT | 52 HR. ENDING | BODY WEIGHT KG. | FLUID OUTPUT | | | | | | FLUID INTAKE | | | | | | SODIUM CHLORIDE LOSSES | | | | | | NACL GIVEN GM. | PLASMA CHLORIDE MG. NACL/100 |
|---------|------------------|--------------------|---------------|-------------------------------------|--------------------|---------------|--|-------------------------------------|----------------------------|---------------------------|---------------|--------------|------------------------------------|--------------------|------------------------|---------------------------------------|-------|-----|-----|-------|-------------------|---------------------------------|
| | | | URINE C.C. | GASTRO- INTESTINAL TRACT C.C. | BILE TRACT C.C. | TOTAL C.C. | TOTAL LOSSES TO BE RE- PLACED C.C. | 5% GLUCOSE INTRAVENOUSLY C.C. | PHYSIOLOGIC SALINE C.C. | WATER (ORALLY) C.C. | TOTAL C.C. | URINE GM. | GASTRO- INTESTINAL TRACT GM. | BILE T-TUBE GM. | TOTAL GM. | TOTAL NACL TO BE RE- PLACED GM. | | | | | | |
| F. K. | 2/18/38 | 40.36 | 1,870 | 320 | 403 | 2,590 | 720 | 4,000 | 0 | 0 | 4,000 | 2.45 | 1.03 | 1.91 | 5.39 | 2.94 | 0 | 556 | 556 | 0 | 556 | |
| | 2/19/38 | 47.86 | 3,650 | 850 | 290 | 4,790 | 1,140 | 3,110 | 708 | 0 | 3,818 | 1.10 | 5.81 | 1.69 | 8.60 | 7.50 | 6.03 | 528 | 528 | 6.03 | 528 | |
| | 2/20/38 | 48.26 | 2,470 | 0 | 290 | 2,760 | 290 | 3,050 | 1,105 | 0 | 4,215 | 1.06 | 0 | 1.75 | 2.81 | 1.75 | 9.90 | 540 | 540 | 9.90 | 540 | |
| | 2/21/38 | 47.67 | 2,770 | 0 | 250 | 3,020 | 250 | 2,075 | 287 | 995 | 3,357 | 1.11 | 0 | 1.49 | 2.60 | 1.49 | 2.44 | 540 | 540 | 2.44 | 540 | |
| | 2/22/38 | 47.44 | 2,170 | 0 | 250 | 2,420 | 250 | 1,020 | 478 | 1,500 | 2,998 | 1.26 | 0 | 1.01 | 2.27 | 1.01 | 4.06 | 564 | 564 | 4.06 | 564 | |
| M. M. | 2/23/38 | Total | 12,930 | 1,170 | 1,480 | 15,580 | 2,650 | 13,255 | 2,638 | 2,495 | 18,388 | 6.98 | 6.84 | 7.85 | 21.67 | 21.67 | 22.43 | 571 | 571 | 22.43 | 571 | |
| | 2/21/38 | 42.01 | --- | --- | --- | --- | --- | 2,970 | 890* | 0 | 3,860 | 6.85 | 0.56 | 0 | 7.41 | 0.56 | 5.86 | 533 | 533 | 5.86 | 533 | |
| | 2/22/38 | 42.62 | 2,100 | 220 | 0 | 2,320 | 220 | 3,000 | 243 | 0 | 3,243 | 1.42 | 2.23 | 0 | 3.65 | 2.23 | 2.07 | 540 | 540 | 2.07 | 540 | |
| | 2/23/38 | 41.32 | 2,963 | 350 | 0 | 3,350 | 350 | 2,730 | 354 | 0 | 3,084 | 1.11 | 2.45 | 0 | 3.56 | 2.45 | 3.01 | 541 | 541 | 3.01 | 541 | |
| | 2/24/38 | 41.65 | 2,180 | 390 | 0 | 2,570 | 390 | 1,990 | 385 | 0 | 2,375 | 1.53 | 0 | 0 | 1.53 | 0 | 3.27 | 545 | 545 | 3.27 | 545 | |
| E. M. | 2/25/38 | 40.26 | 1,460 | 0 | 0 | 1,460 | 0 | 1,090 | 385 | 0 | 2,375 | 10.91 | 5.24 | 0 | 16.15 | 5.24 | 14.21 | 582 | 582 | 14.21 | 582 | |
| | Total | | 8,540 | 960 | 0 | 9,600 | 960 | 10,690 | 1,872 | 0 | 12,562 | --- | --- | --- | --- | --- | --- | 490 | 490 | --- | 490 | |
| | 3/ 9/38 | 58.01 | --- | --- | --- | --- | --- | 4,000 | 0 | 0 | 4,000 | 1.21 | 6.46 | 0 | 7.67 | 6.46 | 7.35 | 492 | 492 | 7.35 | 492 | |
| | 3/10/38 | 59.06 | 1,040 | 900 | 0 | 1,940 | 900 | 3,020 | 865 | 0 | 3,885 | 1.65 | 4.94 | 0 | 6.59 | 4.94 | 7.01 | 505 | 505 | 7.01 | 505 | |
| | 3/11/38 | 57.25 | 2,750 | 840 | 0 | 4,590 | 840 | 3,055 | 835 | 0 | 3,890 | 1.51 | 5.69 | 0 | 7.20 | 5.69 | 7.84 | 490 | 490 | 7.84 | 490 | |
| M. A. | 3/12/38 | 56.85 | 2,820 | 920 | 0 | 3,540 | 920 | 1,400 | 922 | 0 | 2,322 | 0.70 | 5.30 | 0 | 6.00 | 5.30 | 8.76 | 513 | 513 | 8.76 | 513 | |
| | 3/13/38 | 56.30 | 950 | 1,020 | 0 | 1,970 | 1,020 | 1,020 | 1,930 | 650 | 2,700 | 0.80 | 0 | 0 | 0.80 | 0 | 30.96 | 568 | 568 | 30.96 | 568 | |
| | 3/14/38 | 56.50 | 1,250 | 0 | 0 | 1,250 | 0 | 1,020 | 1,930 | 650 | 2,700 | 5.87 | 22.39 | 0 | 28.26 | 22.39 | 30.96 | 490 | 490 | 30.96 | 490 | |
| | Total | | 9,610 | 3,680 | 0 | 13,290 | 3,680 | 12,495 | 3,682 | 650 | 16,797 | --- | --- | --- | --- | --- | --- | 568 | 568 | --- | 568 | |
| | 4/ 5/38 | 54.46 | --- | --- | --- | --- | --- | 3,300 | 0 | 0 | 3,300 | 2.17 | 3.31 | 0.81 | 6.29 | 4.12 | 0 | 490 | 490 | 0 | 490 | |
| M. A. | 4/ 6/38 | --- | 940 | 490 | 160 | 1,590 | 650 | 3,300 | 669 | 0 | 3,300 | 2.17 | 3.31 | 0.81 | 6.29 | 4.12 | 5.69 | 500 | 500 | 5.69 | 500 | |
| | 4/ 7/38 | 53.26 | 3,540 | 780 | 240 | 4,560 | 1,020 | 3,000 | 1,010 | 0 | 3,669 | 3.12 | 5.37 | 1.03 | 9.52 | 6.40 | 8.59 | 512 | 512 | 8.59 | 512 | |
| | 4/ 8/38 | 51.29 | 2,830 | 910 | 230 | 3,970 | 1,140 | 2,000 | 1,010 | 0 | 3,010 | 1.59 | 6.53 | 1.10 | 9.22 | 7.63 | 9.78 | 535 | 535 | 9.78 | 535 | |
| | 4/ 9/38 | 50.87 | 1,880 | 0 | 215 | 2,095 | 215 | 2,000 | 1,150 | 0 | 3,150 | 0.98 | 0 | 1.08 | 2.06 | 1.08 | 1.14 | 545 | 545 | 1.14 | 545 | |
| | 4/10/38 | 50.42 | 2,700 | 0 | 220 | 2,920 | 220 | 2,250 | 393 | 1,000 | 3,643 | 0.76 | 0 | 1.08 | 1.90 | 1.14 | 3.34 | 545 | 545 | 3.34 | 545 | |
| M. A. | 4/10/38 | 50.42 | 2,700 | 0 | 220 | 2,920 | 220 | 2,250 | 393 | 1,000 | 3,643 | 0.76 | 0 | 1.08 | 1.90 | 1.14 | 3.34 | 545 | 545 | 3.34 | 545 | |
| | Total | | 11,890 | 2,180 | 1,065 | 15,135 | 3,245 | 12,550 | 3,222 | 1,000 | 16,772 | 8.62 | 15.21 | 5.16 | 28.99 | 20.37 | 27.40 | 545 | 545 | 27.40 | 545 | |

* 165 c.c. physiologic saline and 425 c.c. blood.

age (in the choledochostomy cases) were measured and their chloride content determined. A blood specimen was also taken for the determination of the plasma chloride concentration. A volume of physiologic saline or Ringer's solution equal to the volume of the drainage for the previous 24 hours was then given intravenously and this was supplemented by sufficient 5 per cent glucose in distilled water to provide for the fluid needs of the body. These patients received nothing by mouth as long as the Levine tube was in place, and none of them had stools during the period of study. Salt losses through the skin were not determined but in no case was there profuse sweating. The fluid drainage in these cases ranged from 220 to 1,960 e.e. per day. The patients did not gain in weight, so it was assumed that an excessive amount of salt leading to the development of subclinical edema had not been given.

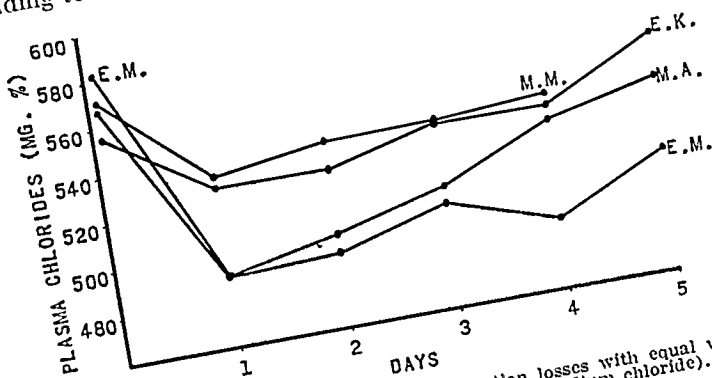


Fig. 3.—Replacement of upper gastrointestinal secretion losses with equal volumes of physiologic saline solution (1 L. equals 8.5 gm. sodium chloride).

The data presented in Fig. 3 illustrate the variations occurring in the plasma chloride level in four patients in whom losses were replaced with equal volumes of physiologic saline solution containing 8.5 gm. of sodium chloride per liter. The detailed figures of the study are given in Table VII. Three of the cases (E. K., M. M., and M. A.) maintained a fairly satisfactory plasma chloride level. Each of these cases also excreted about 1 gm. or more of sodium chloride daily in the urine, indicating, we believe at this time,* that a satisfactory excess of salt had been provided by this volume-for-volume rule. The plasma chlorides of E. M. did not fall to a seriously low level, but, nevertheless, they were definitely below normal. This may have been a failure of the volume-for-volume rule or an example of an individual whose plasma chlorides could not be maintained at a higher level.

Fig. 4 and Table VIII show a series of four cases in which the losses were replaced with equal volumes of Ringer's solution containing the

* This statement needs further investigation.

TABLE VIII
REPLACEMENT OF UPPER GASTROINTESTINAL SECRETION LOSSES WITH EQUAL VOLUMES OF RINGER'S SOLUTION
(1 L. \approx 7.5 Gm. NaCl)

| PATIENT | 24 HR. ENDING | BODY WEIGHT KG. | FLUID OUTPUT | | | | | FLUID INTAKE | | | | | SODIUM CHLORIDE LOSSES | | | | | | PLASMA CHLORIDE MG. NaCl/100 |
|---------|------------------|--------------------|-----------------------|-------|-------------|---------------|--|------------------------|-----------------------------|-------|-------------------|---------------|------------------------|------------------------------------|-------------|--------------|---------------------------------------|-------------------|---------------------------------|
| | | | GASTRO- INTESTINAL | BILE | F-TUBE C.C. | TOTAL C.C. | TOTAL LOSSES TO BE RE- PLACED C.C. | RINGER'S SOLN. C.C. | 5% GLUCOSE INTRAVENOUSLY | C.C. | WATER (ORALLY) | TOTAL C.C. | URINE Gm. | GASTRO- INTESTINAL TRACT Gm. | BILE Gm. | TOTAL Gm. | TOTAL NaCl TO BE RE- PLACED Gm. | NaCl GIVEN Gm. | |
| W. W. | 1/ 4/38 | 81.77 | --- | 1,000 | --- | 2,640 | 1,960 | 0 | 1,750 | --- | --- | 1,750 | --- | --- | --- | 10.70 | 9.97 | --- | 538 |
| | 1/ 5/38 | 80.00 | 963 | --- | --- | 810 | 1,100 | 2,035 | 2,000 | 0 | 0 | 4,035 | 0.73 | 4.15 | 5.82 | 10.70 | 6.88 | --- | 548 |
| | 1/ 6/38 | 78.82 | 290 | 315 | --- | 3,690 | 3,115 | 1,133 | 2,970 | 0 | 0 | 4,103 | 0.54 | 1.84 | 2.03 | 7.42 | 8.35 | 15.36 | 549 |
| | 1/ 7/38 | 77.81 | 0 | 0 | --- | 2,725 | 315 | 1,133 | 3,100 | 0 | 0 | 3,418 | 2.10 | 0 | 0 | 4.13 | 2.03 | 8.35 | 573 |
| | 1/ 8/38 | 76.96 | 0 | 0 | --- | 465 | 465 | 318 | 3,100 | 0 | 0 | 3,418 | 0.35 | 0 | 0 | 0.35 | 0 | 2.30 | 561 |
| | Total | | 1,250 | 2,125 | --- | 9,520 | 3,375 | 3,486 | 9,820 | 0 | --- | 13,306 | 3.72 | 5.99 | 12.89 | 22.60 | 18.88 | 26.21 | |
| J. B. | 1/10/38 | 73.09 | --- | --- | --- | 1,225 | 480 | --- | 4,100 | --- | --- | 4,100 | --- | --- | --- | 6.51 | 2.65 | --- | 596 |
| | 1/11/38 | 74.50 | 480 | --- | --- | 4,255 | 505 | 485 | 4,120 | 0 | 0 | 4,605 | 3.86 | 2.65 | 0 | 8.49 | 3.30 | --- | 545 |
| | 1/12/38 | 73.23 | 505 | --- | --- | 2,800 | 280 | 522 | 3,020 | 0 | 0 | 3,542 | 5.19 | 3.30 | 0 | 8.49 | 3.30 | 3.66 | 538 |
| | 1/13/38 | 72.33 | 280 | 0 | --- | 1,335 | 0 | 318 | 2,040 | 400 | 400 | 2,758 | 0.48 | 1.57 | 0 | 2.05 | 1.57 | 3.81 | 548 |
| | 1/14/38 | 72.07 | 0 | 0 | --- | 825 | 1,265 | 1,325 | 13,280 | 400 | --- | 15,005 | 0.32 | 0 | 0 | 0.32 | 0 | 2.40 | 546 |
| | Total | | 1,265 | 0 | --- | 9,825 | 1,265 | 1,325 | 13,280 | 400 | --- | 15,005 | 9.85 | 7.52 | 0 | 17.37 | 7.52 | 0.87 | |
| A. G. | 1/10/38 | 51.64 | --- | --- | --- | 1,245 | 510 | 800* | 2,000 | --- | --- | 2,800 | --- | --- | --- | --- | --- | --- | 586 |
| | 1/11/38 | --- | 320 | 190 | --- | 4,255 | 955 | 517 | 4,000 | 0 | 0 | 4,517 | 1.61 | 2.47 | 1.04 | 5.12 | 3.51 | 4.80 | 520 |
| | 1/12/38 | 49.65 | 775 | 180 | --- | 3,585 | 985 | 945 | 3,000 | 0 | 0 | 3,945 | 1.02 | 6.07 | 1.11 | 8.20 | 7.18 | 3.90 | 520 |
| | 1/13/38 | 48.78 | 855 | 130 | --- | 3,190 | 930 | 963 | 3,000 | 0 | 0 | 3,963 | 0.82 | 6.67 | 0.82 | 7.98 | 7.49 | 7.13 | 526 |
| | 1/14/38 | 48.25 | 860 | 70 | --- | 1,270 | 150 | 956 | 2,000 | 1,000 | --- | 3,956 | 0.34 | 5.62 | 0.33 | 6.29 | 5.95 | 7.27 | 502 |
| | 1/15/38 | 49.38 | 0 | 150 | --- | 1,545 | 3,530 | 4,181 | 14,000 | 1,000 | --- | 19,181 | 0.27 | 0 | 0.88 | 1.15 | 0.88 | 7.22 | 538 |
| | Total | | 2,810 | 720 | --- | 13,545 | 3,530 | 4,181 | 14,000 | 1,000 | --- | 19,181 | 3.73 | 20.83 | 4.18 | 28.74 | 25.01 | 30.32 | |
| M. L. | 1/24/38 | 52.91 | --- | --- | --- | 3,040 | 860 | --- | 4,000 | --- | --- | 4,000 | --- | --- | --- | --- | --- | --- | 571 |
| | 1/25/38 | 52.15 | 570 | --- | --- | 4,270 | 880 | 835 | 3,000 | 0 | 0 | 3,895 | 4.82 | 4.01 | 1.59 | 10.42 | 5.60 | 0 | 505 |
| | 1/26/38 | 49.85 | 540 | 340 | --- | 3,690 | 770 | 930 | 2,975 | 0 | 0 | 3,895 | 0.51 | 2.99 | 1.63 | 5.13 | 4.62 | 6.30 | 530 |
| | 1/27/38 | 49.76 | 520 | 250 | --- | 3,050 | 300 | 787 | 2,080 | 0 | 0 | 2,867 | 0.17 | 3.49 | 0.92 | 4.58 | 4.41 | 6.79 | 535 |
| | 1/28/38 | 49.06 | 0 | 260 | --- | 2,130 | 260 | 317 | 1,030 | 1,100 | --- | 2,447 | 0.06 | 0 | 1.26 | 1.32 | 1.26 | 5.93 | 521 |
| | 1/29/38 | 49.06 | 0 | 260 | --- | 1,650 | 3,070 | 2,839 | 13,145 | 1,100 | --- | 17,084 | 0.13 | 0 | 1.57 | 1.70 | 1.57 | 2.39 | 531 |
| | Total | | 1,650 | 1,440 | --- | 16,150 | 3,070 | 2,839 | 13,145 | 1,100 | --- | 17,084 | 5.69 | 10.49 | 6.97 | 23.15 | 17.46 | 21.41 | |

*300 c.c. physiologic saline and 500 c.c. blood.

equivalent of 7.5 gm. of sodium chloride per liter.* It will be noted that all of the cases maintained a fairly satisfactory plasma chloride level, but in each the daily urinary excretion of salt fell below 1 gm. indicating that an insufficient excess of salt had been administered.

In all except one of the cases in Figs. 3 and 4 (W. W. in Fig. 4), there was a definite fall in the plasma chloride concentration during the first 24 hours of gastrointestinal fluid drainage, no salt being given during this period. A fairly constant level was maintained thereafter by the volume-for-volume replacement with a tendency in most cases for the level to rise on the last day. In an attempt to eliminate this initial drop and thus maintain the plasma chlorides at a more satisfactory level a series of four cases was studied in which arbitrarily about 1,000 c.c. of physiologic saline solution was given during the first 24 hours. Thereafter the losses were replaced volume-for-volume with physiologic saline solution as in the previous cases.

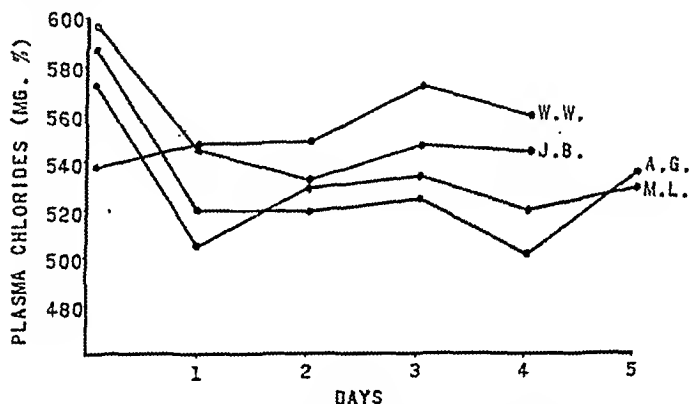


Fig. 4.—Replacement of upper gastrointestinal secretion losses with equal volumes of Ringer's solution (1 L. equals 7.55 gm. sodium chloride).

The results of this study are shown in Fig. 5 and Table IX. It will be seen that three of the cases (T. D., L. W., and M. L.) showed an initial drop in the plasma chlorides in spite of the administration during the first 24 hours of more than sufficient saline solution to balance the abnormal losses during this period. However, the fall was not as marked as in the preceding cases in which no saline solution was given during the first day, and the plasma chloride levels maintained were higher than in the previous cases. This procedure, therefore, appears to be a valuable addition to the volume-for-volume rule.

In summary, the prevention of hypochloremia depends upon the adequate replacement of abnormal losses of chlorides from the body. These studies indicate that this can be accomplished by replacing abnormal fluid losses with equal volumes of physiologic saline solution. This iso-

*Ringer's solution as made by different laboratories varies in its composition. Locke-Ringer's solution U.S.P. contains 9.6 gm. of chloride expressed as sodium chloride.

tonic solution provides not only for the sodium and chloride losses but also for the water losses. In view of the fact that most surgical patients lose sodium dichloride during the first 24 hours after operation, it is advisable to give in addition about 1 L. of physiologic saline solution during this period to decrease the initial fall in the plasma chloride concentration which frequently occurs. If it is apparent that the patient will lose more than 1,000 c.c. of gastrointestinal or other secretions during this period, the amount of saline solution given during the first 24 hours should be increased accordingly.

This volume-for-volume replacement rule is of practical importance in the management of patients losing fluids abnormally while under the care of a physician. Such patients may be vomiting or may have diarrhea, but the rule is most useful in patients in whom continuous gastroduodenal suction is used. One precaution must be observed in such instances. Some physicians allow patients with intubating gastro-

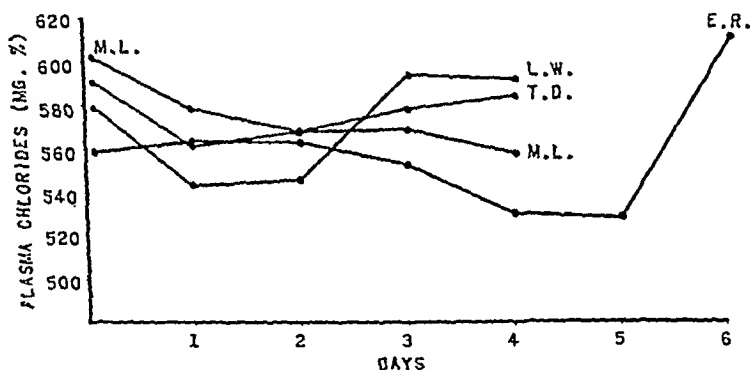


Fig. 5.—Replacement of upper gastrointestinal secretion losses with physiologic saline solution plus 1,000 c.c. of physiologic saline during the first 24 hours.

duodenal suction to take water by mouth or irrigate the tube with water. Most, but not all, of this water will be promptly aspirated, but in it will be dissolved small but significant amounts of chlorides drawn from the body. If the amount of water drunk or used for irrigation is deducted from the total drainage and the remaining portion replaced by the volume-for-volume rule, a definite deficit will be introduced and the patient will probably develop salt deficiency. On the other hand, if the total drainage including the water drunk and used for irrigation is replaced with an equal volume of physiologic saline solution, unnecessarily large quantities of salt will be given with its attendant dangers. In order to avoid such complicating factors we believe that the Levine tube should be irrigated with air rather than water and the patient should be allowed only sufficient ice chips by mouth to keep him comfortable.

(To be continued in the October issue. The references will accompany the second section.)

TABLE IX

REPLACEMENT OF GASTROINTESTINAL SECRETION LOSSES WITH EQUAL VOLUMES OF PHYSIOLOGIC SALINE SOLUTION PLUS 1,000 C.C. OF PHYSIOLOGIC SALINE DURING THE FIRST 24 HOURS

| PATIENT | T. D. | 24 HR. ENDING | FLUID OUTPUT | | | | FLUID INTAKE | | | | | | | | | | SODIUM CHLORIDE LOSSES | | | | | | | | | | NACL GIVEN G.M. | PLASMA CL. MG. NACL/100 C.C. | | |
|---------|---------|---------------|--------------|-----------------------|------------|-------------|--------------|------------|-----------------------------|---|---------------------------|--------|--------------|------------|------------|-----------------------|------------------------|-----------|------------|------------------------------|-------|-------|-------|-------|-------|-------|--------------------|---------------------------------|-------|-------|
| | | | URINE C.C. | GASTROIN- TESTINAL | TRACT C.C. | BILE T-TUBE | C.C. | TOTAL C.C. | TOTAL TO BE REFL'D. C.C. | PHYSIOLOGIC SALINE INTRA- VENOUS C.C. | 5% GLUCOSE INTRAVENOUS | C.C. | WATER ORALLY | TOTAL C.C. | URINE GAL. | GASTROIN- TESTINAL | TRACT G.M. | BILE GAL. | TOTAL GAL. | TOTAL TO BE REPLACED GAL. | | | | | | | | | | |
| T. D. | 3/16/38 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3/17/38 | 66.20 | 1,200 | 120 | 0 | 0 | 0 | 1,320 | 120 | 1,050 | 2,700 | 0 | 0 | 3,750 | 3.77 | 0.80 | 0 | 0 | 4.57 | 0.80 | 8.91 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 | 561 |
| | 3/18/38 | 65.15 | 2,190 | 110 | 0 | 0 | 0 | 2,300 | 110 | 120 | 3,000 | 0 | 0 | 3,120 | 1.01 | 0.76 | 0 | 0 | 1.77 | 0.76 | 1.02 | 568 | 568 | 568 | 568 | 568 | 568 | 568 | 568 | 568 |
| | 3/19/38 | 63.62 | 2,830 | 335 | 0 | 0 | 0 | 3,165 | 335 | 110 | 2,000 | 0 | 0 | 3,110 | 1.33 | 2.27 | 0 | 0 | 3.60 | 2.27 | 0.93 | 578 | 578 | 578 | 578 | 578 | 578 | 578 | 578 | 578 |
| | 3/20/38 | 64.03 | 630 | 0 | 0 | 0 | 0 | 630 | 0 | 342 | 1,000 | 1,000 | 0 | 2,342 | 0.50 | 0 | 0 | 0 | 0.50 | 0 | 2.91 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 | 584 |
| E. R. | 3/19/38 | 46.56 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3/20/38 | 47.29 | 560 | 630 | 0 | 0 | 0 | 1,190 | 630 | 1,010 | 2,600 | 0 | 0 | 3,610 | 0.36 | 4.50 | 0 | 0 | 4.86 | 4.50 | 8.60 | 663 | 663 | 663 | 663 | 663 | 663 | 663 | 663 | 663 |
| | 3/21/38 | 45.30 | 3,260 | 1,020 | 0 | 0 | 0 | 4,280 | 1,020 | 630 | 3,000 | 0 | 0 | 3,630 | 0.46 | 7.52 | 0 | 0 | 7.99 | 7.52 | 5.36 | 563 | 563 | 563 | 563 | 563 | 563 | 563 | 563 | 563 |
| | 3/22/38 | 44.11 | 1,160 | 1,890 | 0 | 0 | 0 | 3,050 | 1,890 | 1,020 | 2,000 | 0 | 0 | 3,020 | 0.13 | 12.36 | 0 | 0 | 12.49 | 12.36 | 8.65 | 553 | 553 | 553 | 553 | 553 | 553 | 553 | 553 | 553 |
| | 3/23/38 | 43.21 | 1,300 | 2,500 | 0 | 0 | 0 | 3,800 | 2,500 | 1,920 | 2,000 | 0 | 0 | 3,920 | 0.09 | 19.28 | 0 | 0 | 19.37 | 19.28 | 16.32 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 |
| L. W. | 3/24/38 | 43.17 | 360 | 3,000 | 0 | 0 | 0 | 3,360 | 3,000 | 2,510 | 1,000 | 240 | 0 | 3,750 | 0.14 | 20.76 | 0 | 0 | 20.90 | 20.76 | 21.33 | 528 | 528 | 528 | 528 | 528 | 528 | 528 | 528 | 528 |
| | 3/25/38 | 42.54 | 440 | 2,330 | 0 | 0 | 0 | 2,770 | 2,330 | 2,080 | 0 | 0 | 0 | 3,080 | 0.41 | 15.38 | 0 | 0 | 15.79 | 15.38 | 26.20 | 611 | 611 | 611 | 611 | 611 | 611 | 611 | 611 | 611 |
| | Total | | 7,080 | 11,370 | 0 | 0 | 0 | 18,450 | 11,370 | 10,600 | 240 | 21,010 | 1.59 | 79.81 | 0 | 81.40 | 79.81 | 86.46 | 81.40 | 79.81 | 86.46 | | | | | | | | | |
| | 3/25/38 | 58.09 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3/23/38 | 59.22 | 310 | 320 | 0 | 0 | 0 | 630 | 320 | 1,060 | 2,000 | 0 | 0 | 3,060 | 3.08 | 1.96 | 0 | 0 | 5.04 | 1.96 | 9.01 | 543 | 543 | 543 | 543 | 543 | 543 | 543 | 543 | 543 |
| M. L. | 3/24/38 | 57.09 | 3,680 | 310 | 0 | 0 | 0 | 3,990 | 310 | 325 | 3,000 | 0 | 0 | 3,325 | 9.02 | 1.82 | 0 | 0 | 10.84 | 1.82 | 2.76 | 546 | 546 | 546 | 546 | 546 | 546 | 546 | 546 | 546 |
| | 3/25/38 | 54.45 | 3,230 | 600 | 0 | 0 | 0 | 3,830 | 600 | 314 | 2,000 | 0 | 0 | 2,314 | 1.97 | 4.01 | 0 | 0 | 5.98 | 4.01 | 2.67 | 594 | 594 | 594 | 594 | 594 | 594 | 594 | 594 | 594 |
| | 3/26/38 | 55.46 | 280 | 0 | 0 | 0 | 0 | 280 | 0 | 582 | 500 | 1,400 | 0 | 2,482 | 0.64 | 0 | 0 | 0 | 0.64 | 0 | 4.91 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 |
| | Total | | 7,500 | 1,230 | 0 | 0 | 0 | 8,730 | 1,230 | 2,281 | 7,500 | 1,400 | 11,181 | 14.71 | 7.79 | 0 | 0 | 22.50 | 7.79 | 19.35 | 19.35 | | | | | | | | | |
| | 4/12/38 | 40.08 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| M. L. | 4/13/38 | 40.94 | 1,160 | 260 | 0 | 0 | 0 | 1,420 | 260 | 1,606* | 2,000 | 0 | 0 | 3,606 | 1.33 | 1.59 | 0 | 0 | 2.92 | 1.59 | 1.41 | 578 | 578 | 578 | 578 | 578 | 578 | 578 | 578 | 578 |
| | 4/14/38 | 39.08 | 3,230 | 250 | 0 | 0 | 0 | 3,480 | 250 | 486 | 3,000 | 0 | 0 | 3,486 | 4.81 | 1.69 | 0 | 0 | 6.50 | 1.69 | 4.13 | 568 | 568 | 568 | 568 | 568 | 568 | 568 | 568 | 568 |
| | 4/15/38 | 38.87 | 1,620 | 0 | 0 | 0 | 0 | 1,620 | 0 | 370 | 632 | 2,500 | 0 | 3,132 | 1.59 | 0 | 0 | 0 | 3.66 | 0 | 5.37 | 569 | 569 | 569 | 569 | 569 | 569 | 569 | 569 | 569 |
| | 4/16/38 | 37.64 | 730 | 0 | 0 | 0 | 0 | 730 | 0 | 390 | 722 | 1,000 | 800 | 2,522 | 2.12 | 0 | 0 | 0 | 2.17 | 0 | 6.14 | 558 | 558 | 558 | 558 | 558 | 558 | 558 | 558 | 558 |
| M. L. | Total | | 6,740 | 510 | 1,370 | 8,620 | 1,880 | 3,440 | 8,590 | 800 | 12,740 | 9.85 | 3.28 | 7.52 | 20.65 | 10.80 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 | 17.05 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

*1,000 cc physiological saline and 500 cc. blood.

*1,000 c.c. physiologic saline and 500 c.c. blood.

program." He suggests a board from the A. M. A., American College of Surgeons, and other organizations to inspect and standardize hospitals upon a basis of training the young surgeon.

A National Council on Medical Education: Willard C. Rappleye, New York, N. Y., Dean of Columbia University and president-elect of the Association of American Medical Colleges.—"The educational problems of medicine from college preparation to retirement from practice, should be regarded merely as different phases of the training of personnel to meet the health needs of the country. Portions of the training are primarily within the jurisdiction of universities and medical schools, some are largely within the domain of the hospitals, others are in the various fields of practice, and some are under direct governmental regulations. There is urgent need for co-ordination of the various subdivisions of medical education and of the programs of national and state agencies, universities, hospitals and professional bodies dealing with portions of the whole program. The logical conclusion from the present unrelated and frequently overlapping efforts is to secure a national co-ordinating body representative of the major activities in medical education. A National Council on Medical Education, Licensure, and Hospitals should be created, made up of representatives of the universities, medical schools, hospitals, practicing profession, specialty boards, state licensing bodies, and public health agencies. The functions of a National Medical Council would be those of studying the major educational needs of American medicine, of formulating adequate standards of training at the several levels and of advising regulatory bodies, universities, hospitals and governmental agencies on standards, methods and procedures. A central clearing house for authoritative judgement and advice on matters dealing with all features of medical education, transcending the activities and interests of any one group or organization, would be of the greatest practical value to the future health program of the entire country."

Discussed by Evarts A. Graham, St. Louis, Mo., and Harold Rypins, of the New York Board of Medical Examiners.

Replacement of Sodium Chloride in Surgical Patients: Frederiek A. Collier, Robert M. Bartlett, Ann Arbor, Mich., Svend Pedersen, Dermid L. C. Bingham, and Walter G. Maddock, Ann Arbor, Mich.—"The problem of maintaining a satisfactory electrolyte balance in surgical patients losing gastrointestinal secretions has been frequently discussed, but the amount of salt given has been largely on an empirical basis. The dangers of overloading a patient with salt have been known for some time and the equally important dangers of depletion of body chlorides have also been recognized. Quantitative studies have been undertaken on two phases of the problem: (1) how much salt does a patient who has had prolonged vomiting or other abnormal losses of body fluids need to restore the blood chlorides to a normal level, and (2) how much salt does a patient losing his gastrointestinal secretions while under observation, as on continuous gastroduodenal suction, need to maintain his blood chlorides at a normal level. In the patient entering the hospital with depleted body chlorides, studies tend to show that if the surgeon knows the body weight of the patient and the blood chloride level he can calculate by means of a simple formula the number of grams of salt that should be administered to the patient to restore his electrolyte balance to normal. Results indicate that by replacing the drainage from Wangensteen suction volume for volume with physiological saline or Ringer's solution, the blood chlorides will be maintained at their original level and yet the body will not be overloaded with an excessive amount of salt."

Discussion by Thomas G. Orr, Kansas City, Mo.—"Sodium chloride may be given in excess and do harm especially when the patient has a low proteid state, even though there would be no danger in good health."

Review of Recent Meetings

REVIEW OF THE MEETING OF THE AMERICAN SURGICAL ASSOCIATION, ATLANTIC CITY, N. J., MAY 2-4, 1938

ALBERT O. SINGLETON, M.D., GALVESTON, TEX.

The Therapeutic Management of Urinary Infections: Alexander Randall, Philadelphia, Pa., and Boland Hughes.—“All urinary infections are of either hematogenous or urogenous (adnexal) origin. Rational treatment should be directed first towards eliminating the infectious focus or foci feeding the urinary tract. So far as the urinary infection per se is concerned, three cardinal principles govern the treatment. (1) Removal of all causes of urinary stasis; (2) determination of adequacy of kidney function to excrete the chosen antiseptic in sufficient concentration to obtain therapeutic effect; (3) selection of the proper antiseptic for specific action on the infecting organism.”

Thymol Therapy in Actinomycosis: Thomas M. Joyce, Portland, Ore.—“Experiments with various volatile oils have demonstrated that thymol is the most efficacious in destroying certain types of yeasts. A culture of actinomycosis proved readily susceptible to an aqueous solution of thymol, but resistant to other oils. A case of cervicofacial actinomycosis, treated by the oral administration of thymol with definite improvement, was reported by Myers and Thienes in 1925. After further experimentation Myers, 1927, concluded that powdered thymol in capsules by mouth was absorbed and circulated in sufficient strength to have pronounced fungicidal effect on two patients with pulmonary moniliosis and one with actinomycosis; also he felt that localized superficial mycotic infections may be treated with solutions of the oils and thymol in alcohol, ether, or olive oil, in strength according to local irritability of the tissues.”

Thymol was found (1925) to cure mycelia. It is given 5 per cent in cinnamon oil orally, $\frac{1}{2}$ gr. (in capsule) daily. A 10 per cent solution in oil is injected in the sinuses daily. Six cases were reported improved or cured with the treatment.

Discussed by: Owen H. Wangensteen, Minneapolis, Minn., who has succeeded equally well by surgery alone. Based upon the fact that the infection is anaerobic and grows in dead tissue, curettement seems to be all that is necessary.

The Education and Training of a Surgeon (Presidential Address): Arthur W. Elting, Albany, N. Y.—Dr. Elting made a strong plea for activity of hospitals in this problem. Each hospital should and could provide training for the young surgeon with little added expense and improvement in the service to the patients. Surgeons as a group should sponsor such a plan. The usual extravagance of the surgeon should be directed to financing such a plan in the hospital. At the present time only forty-four hospitals in the United States give as much as three years' training to young surgeons. Dr. Elting also discussed the nursing school problem. He said “training of nurses is in the hands of women with a great crusading zeal, and though the surgeon has to use the nurse he has too little to do with her training

as nausea, vomiting, cyanosis, acidosis, skin rashes, fever, acute hemolytic anemia and agranulocytosis. It will be our purpose in this communication to discuss methods of administration of sulfanilamide or 'prontosil solution,' the indications for the use of these drugs, the toxic effects noted as the result of sulfanilamide therapy, and the therapeutic effects obtained in certain bacterial diseases." Discussion by Dean Lewis, Baltimore, Md.

The Action of Sulfanilamide Upon Hemolytic Streptococci: Dr. Champ Lyons, Baltimore, Md., and Richard H. Miller, Boston, Mass.—"Experiments are reported to demonstrate that sulfanilamide acts upon hemolytic streptococci to: (1) Prolong the 'lag phase' of growth without being truly bacteriostatic or bactericidal; (2) alter the physicochemical structure of the capsule; (3) attenuate the virulence of the organisms. Clinical and laboratory results are correlated to demonstrate: (1) Patients with no antibacterial antibody and highly virulent organisms require large doses of sulfanilamide over a long period of time (7 to 10 days). (2) Patients with no antibacterial antibody and less virulent organisms require large doses of sulfanilamide over short periods of time (48 to 72 hours.) (3) Patients with antibacterial antibody require lower doses over short periods of time (48 to 72 hours), regardless of the virulence of the organism."

These papers were discussed freely with many favorable reports of its use and very few unfavorable reports in the treatment of most all varieties of infection. There seem to be, as yet, few rules restricting its use.

Regional Ileitis: Claude F. Dixon, Rochester, Minn.—"Regional ileitis may involve either the small or large intestine. Cause unknown. Terminal ileum is most common site. The disease is being discovered much more often than in the past and is becoming known as a distinct entity. The complications are perforation into other organs and fistula formation. The treatment is surgical." He reports 30 cases, 87 per cent in the ileum, ages 30 to 40. Many have fistulas. With 39 cases of Pemberton and Brown there were 69 cases. Of these 25 had ileo-colostomy and 5 were cured; 40 cases were resected, 4 died, 34 are well. Advocates one or two stage operation. He prefers to call the disease Regional Enteritis.

Discussed by Horace Binney, Boston, Mass.; E. P. Lehman, University, Va.; H. H. Kerr, Washington, D. C.; C. G. Mixter, and John Homans, Boston, Mass.—Some cases were reported cured by no treatment, while others were more radical. Also, even after resections, some cases of recurrence were reported. The etiology was unknown.

The Rapid Control of Intracranial Pressure: Erwin R. Schmidt, Madison, Wis.—"Our present methods to control increased intracranial pressure require some time to be effective and depend on physiologic principles. The method we wish to present depends on mechanics alone, is rapid, and is effective in a large percentage of the cases. By means of a ventricular puncture, a drain is inserted and the cerebrospinal fluid can be removed and any fluid that is produced can escape, making the reduction permanent as long as the drain remains in place. We have used it in twenty cases for the following indications: (1) preoperative reduction of cranial pressure to help stabilize the patient and to prevent sudden changes at the time of operation; (2) postoperatively to prevent pressure developing and making for a smoother convalescence; (3) where operation has failed to remove the cause of the pressure, to make a smoother convalescence and to put the patient in better shape for radiation therapy; (4) to aid in preoperative diagnosis; (5) by using a ventricular drain, emergency operations following ventriculography are not necessary; (6) cerebral hernia can be controlled by ventricular drainage." Ureteral

The Repair of Abdominal Incisions: Allen O. Whipple, New York, N. Y.—“Certain large hospitals have reported 2 per cent to 6 per cent of wound disruption, especially following operations in the upper abdomen. In an effort to repair abdominal wounds, a technique has been developed that has yielded far better results than formerly. In a series of 314 cases, chiefly upper abdominal, silk was used in 212 and catgut in 102. The same principle was carried out with both suture materials: (1) Accurate apposition of the peritoneum and posterior muscle sheath by continuous suture followed by interrupted suture. Anterior rectus sheath closed by the vertical suture, the “far-and-near stitch.” Interrupted sutures used for this layer also. Skin and subcutaneous tissues sutured with interrupted silk. (2) Suture material, whether silk or chromic, much finer than usually employed, and of a strength no greater than the strength of the tissues holding the suture. Silk grade C or O catgut was used. (3) Because of the principles of the far-and-near stitch and the use of interrupted sutures tension on the tissues was eliminated. (4) No retention sutures were used. Wound disruptions have been reduced to less than 1 per cent and postoperative hernias have decreased and are, also, in the neighborhood of 1 per cent.”

Discussed by Samuel C. Harvey, New Haven, Conn.; A. O. Singleton, Galveston, Tex.; Roscoe R. Graham, Toronto, Ontario; Walter D. Wise, Baltimore, Md.; Charles C. Lund, Boston, Mass.; and P. E. Truesdale, Fall River, Mass. The discussion related to various phases of wound disruption, including suture material, knots, surgical technique, infection, hemorrhage, and the importance of the selection of anatomic incisions, as well as allergy, low vitality, etc.

Observations on the Mode of Action of Sulfanilamide and Its Application to Surgical Infections: John S. Lockwood, New York, N. Y.—“Clinical and experimental observations from a wide variety of sources have demonstrated the spectacular therapeutic effectiveness of sulfanilamide in certain types of lesion, and lesser degrees of effectiveness in other types. The explanation of such variations, the rational application of sulfanilamide to specific clinical lesions, and the interpretation of therapeutic results await the formulation of a precise understanding of the mode of action of the drug. Laboratory and clinical evidence will be presented to support the belief that sulfanilamide destroys the invasiveness of organisms having or potentially having this property. Sulfanilamide acts directly or indirectly on invasive organisms to prevent their utilization of tissue and serum protein as a source of nitrogen for reproduction, which is a capacity essential to organisms in producing invasive lesions. It does not bring about bacterial death if peptones, or similar substances found in devitalized tissue, are present to satisfy the nutritional requirements of nitrogen metabolism. Sulfanilamide in high dilution will bring about rapid death of virulent hemolytic streptococci inoculated into peptone-free serum, but the addition of small amounts of peptone prevents such action. By inference from these experiments and from clinical experience, it is possible to conclude that sulfanilamide will act with maximal effectiveness in lesions characterized by minimal traumatic or bacterial necrosis of tissue, and least effectively in lesions well supplied with products of tissue breakdown.”

The Chemotherapy of Bacterial Infections: Perrin H. Long and Eleanor A. Bliss, Baltimore, Md.—“During the last two years several hundred patients suffering from streptococcal, meningococcal, gonococcal, and certain other bacterial infections have been treated in the wards of the Johns Hopkins Hospital with sulfanilamide or ‘prontosil solution.’ In general, the therapeutic effects of sulfanilamide in the treatment of susceptible infections have been brilliant. Certain of the treated patients have shown various toxic manifestations of the drug, such

the progress of symptoms or to prevent death. Adequate controls have been carried out for each experiment. It seems that tetanus toxin is altered in the spinal cord of dogs and that a more potent substance is formed which causes death by respiratory failure."

Discussed by Peter Heinbecker, St. Louis, Mo., who was unable to say that local tetanus was not in muscles but toxin was in the central nervous system definitely; also, that tetanus toxin is easily changed by dilution with peptones, etc. Experimentally, if taken from crushed cord and modified, it may become more virulent. Tetanus toxin acts as strychnine on the central nervous system.

Sensory Denervation of the Bladder for Relief of Intractable Vesical Pain: W. J. Merle Scott, Rochester, N. Y., and Carlisle F. Schroeder, Detroit, Mich.—"The scant and rather conflicting literature concerning the relief of intractable bladder pain is reviewed. The previous methods of accomplishing this have not been very satisfactory. This paper reports ten cases of tuberculosis of the bladder and interstitial cystitis, in which a satisfactory sensory denervation of the bladder has been achieved. A standardized operation is offered to relieve this excruciating pain." In the three interstitial cystitis cases there was no relief after sympathectomy because in those the fundus of the bladder, rather than the trigone, was involved. The denervation consists of removal of the suprahypogastric sympathetic plexus, also denervation of the hemorrhoidal artery. The denervation may be reinforced by small amounts of alcohol in the spinal canal. Discussed by: Loyal Davis, Chicago, Ill. He approved the procedure but felt it would not succeed 100 per cent.

Injuries to the Recurrent Laryngeal Nerve in Thyroid Operations: Their Management and Avoidance: Frank H. Lahey and W. B. Hoover, Boston, Mass.—"Variations in the recurrent nerve in normal states, variations in pathological states, variations in developmental defects. Relation of loss of voice and breathing difficulties to nerve injuries. Anatomical points at which nerves most often injured and reasons why. Method by which injury to nerves may be avoided. Results of complete dissection of the recurrent laryngeal nerve in all thyroid operations for three years. Number of injuries reduced from 3 per cent to $\frac{1}{2}$ per cent. Report of case in which both recurrent laryngeal nerves severed ten months previously were resutured. Cannot always depend upon sutures. Description of an operative procedure devised by Dr. Walter B. Hoover, successfully applied in six cases for bilateral abductor paralysis together with reports of end results, tracheotomy tubes dispensed with postoperatively in all cases. It consists of submucous excision of scar of cord by laryngofissure. Possibility of anastomosing nerves other than recurrent nerves in recurrent laryngeal paralysis with gaps too large for direct anastomosis, as the phrenic."

Dr. Hoover: Paralysis of one cord causes loss of voice for a while but recovers in few months while loss of both cords results in great narrowing and can hardly do without tracheotomy by laryngofissure and dissecting out the cord gives room and relief.

Discussed by Frederick A. Coller, Ann Arbor, Mich.—More recurrent laryngeal nerves are injured than we think, maybe unrecognized. Coller also advises exposure of the nerve in thyroidectomy. The right nerve is more often injured and should be exposed. Also discussed by Mont R. Reid, Cincinnati, Ohio; Edward D. Churchill and Elliot C. Cutler, Boston, Mass.

Progressive Exophthalmos Associated with Disorders of the Thyroid: Howard C. Naffziger, San Francisco, Calif.—"In 1930, a patient with severe and rapidly

catheter used and may be changed occasionally. There is slight danger of infection. There are twenty-four cases reported in which it was used.

A. W. Adson, Rochester, Minn., discussed the paper and also recommended the drain.

The Treatment of Cranial Osteomyelitis and Brain Abscess: A. W. Adson, Rochester, Minn.—“Osteomyelitis of the cranial bones develops from extending infections of the nasal sinuses, mastoids, contaminated compound fractures of the skull and infections of the scalp. Denuded skull areas resulting from lacerated scalp wounds, electric burns and the removal of the scalp with a tumor invariably become osteomyelitic and require similar treatment to that employed in a frank osteomyelitis of cranial bones. The infection may involve either one or both tables of the skull. It usually spreads in a serpiginous course along the diploic canals, but it can communicate superficially with the periosteum and scalp and internally with veins of the dura and brain through the emissary venous system. Prompt adequate drainage and sequestrectomy are necessary to control the infection and to prevent cerebral abscess formation. However, if a brain abscess has developed with the osteomyelitis, the disease should be treated as two distinct lesions. The osteomyelitis deserves prompt surgical attention; whereas, the brain abscess should be treated as a progressing furuncle or abscess in other parts of the body. The treatment consists of supportive measures until the walling-off process has taken place. The time required for encapsulation depends upon the virulence of the organism and the ability of the patient to develop an immunity. This period varies from ten days to three weeks. The initial symptoms of a high septic temperature, leucocytosis, general malaise, and stupor begin to subside as soon as immunity develops. The patient appears to improve but fails to make a complete recovery. The daily temperature rises slightly above normal. The leucocytosis averages about 12,000 and the cerebral symptoms improve except those due to increased intracranial pressure and cerebral localization. The most suitable time to drain an abscess is when immunity and encapsulation have been accomplished since there is less danger of spreading the infection and a greater opportunity to relieve the increased intracranial pressure.”

Discussed by T. C. Grant, Philadelphia, Pa., who prefers the smaller openings and repeated tapping of the abscess or small drain. Gilbert Horrax, Boston, Mass., uses both methods and sometimes extirpates the abscess. J. M. Mason, Birmingham, Ala., reported a case of osteomyelitis from an electric burn and advocates early removal of devitalized outer table of skull.

The Alteration of Tetanus Toxin Within the Spinal Cord: Warfield M. Firor and Austin Lamont, Baltimore, Md.—“A technique has been devised for the accurate injection of minute amounts of tetanus toxin into various parts of the dog's spinal cord. By this procedure it is possible to produce pure reflex motor tetanus without the slightest evidence of peripheral spasm or muscular rigidity. Furthermore, the intraspinal injection of a fraction (1/120 to 1/100) of an ordinary lethal dose is always followed by the death of the animal. The mechanism of death is respiratory failure. The obvious explanation that the toxin passes up the cord is not tenable because death occurs when the toxin is introduced into the distal segment of a transected cord. In four instances it has been possible to cause the death of other dogs by intramuscular injections of the segment of cord in which a sublethal amount of tetanus toxin had been previously deposited. The intracerebral injection of minute amounts of tetanus toxin has not as yet produced symptoms or caused death. The intravenous administration of a hundred times the neutralizing dose of antitoxin one hour after an intraspinal injection fails to halt

the progress of symptoms or to prevent death. Adequate controls have been carried out for each experiment. It seems that tetanus toxin is altered in the spinal cord of dogs and that a more potent substance is formed which causes death by respiratory failure."

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progressive exophthalmos, which began some time after a thyroideectomy, presented herself with failing vision, some swelling of the optic disks, and threatened desiccation of the cornea. Investigation of the literature indicated no known pathologic cause for the condition, but a wide variety of treatments, varying from sympathectomy to sutures of the lids, had been employed in attempts to palliate the condition. For our patient we planned a direct investigation of the orbit which would also be a decompressive operation. A myopathy was found to be responsible for the proptosis, and the characteristic pathological picture was revealed on the examination of small biopsy specimen. The treatment was highly satisfactory and a similar operation was later performed on the opposite side in this same patient. Since the presentation of this first case, a number of other patients have been operated on, and a large number of examinations have revealed the constancy of the pathological change in the muscles. The original operation has been modified to increase its effectiveness, and attempts have been made by experimental study, to throw light on the etiology of the condition. To date these studies have not been conclusive, but, in connection with the clinical relationships involved in progressive exophthalmos, they have thrown interesting sidelights on the condition."

Discussed by Thomas M. Joyee, Portland, Ore.; Martin B. Tinker, Ithaca, N. Y.; Harry B. Zimmerman, St. Paul, Minn., who all praised the operation. Frank H. Lahey, Boston, Mass., reported superior cervical sympathetic ganglionectomy in mild cases of exophthalmos to be a good procedure.

Amount of Thyroid Remnant in Operations for Diffuse Toxic Goiter: Morris K. Smith, New York, N. Y.—"Amount of normal gland that will protect against permanent hypothyroidism is very small. Development of modern radical resection. Review of opinions of various surgeons which varied. A study of the relation of the size of remnants left at operation in a series of cases (about 70) to the postoperative course. As far as carried out, it indicates that in general among those left with smaller remnants there was a lower incidence of postoperative hyperthyroidism. However, if the series is divided into two groups according to the size of the remnant the combined postoperative metabolic curve of the group with larger remnants is as satisfactory as that of those with lesser remnants. Four to 10 gm. of thyroid tissue depending on the size of gland, severity of intoxication and response to iodine should ordinarily meet the indications." The gland regenerates greatly. There is some danger of taking too much, producing hypothyroidism. We leave more than we think usually, 4 to 6 gm. enough to leave.

Discussed by W. B. Parsons, New York, N. Y., and M. B. Tinker, Ithaca, N. Y. Both urged conservative operation and second operation rather than myxedema.

Further Observations Upon Arteriovenous Aneurysms and Abnormal Arteriovenous Communications: Mont R. Reid and Johnson McGuire, Cincinnati, Ohio.—"Since publication of our series of arteriovenous and cirroid aneurysms in 1920, 30 additional cases have been studied. Interesting observations have been made upon the effect of such lesions on the heart, circulation time, blood volume, venous pressure, etc. Conditions have arisen which made it impossible to use any of the standard procedures for operating upon arteriovenous aneurysms. Two additional operative procedures have been devised where the fistula cannot be directly attacked. One of these is the twisting of the vein to occlude the fistula, and the other is direct transfixation closure of the fistula by passing a double suture directly through the vein and tying it in a V-shape so as to obliterate the opening. Acute and chronic experiments have been undertaken in the laboratory. In the acute experiments artificial anastomosis between the aorta and the vena cava have been made and the

effects noted. A Venturi tube, so constructed as to measure the volume of blood flow, was placed in the vena cava between the fistula and the heart in two instances. A tremendous increase in the volume of blood being returned to the heart through the vena cava was recorded. We are not able to demonstrate, either experimentally or clinically, a marked rise in venous pressure between the fistula and the heart, as has been reported by some other investigators. Neither are we convinced that the immediate effect upon the heart is a decrease in its size. In addition to the acute experiments we wish to report some observations made upon chronic cases of arteriovenous fistula produced in dogs." Detailed report of cases with drawings of the technique of each operation was shown.

Discussed by James M. Mason, Birmingham, Ala., who recited history of the discovery of the relations of arteriovenous fistula and heart disease. He also reported cases of his own. Edwin P. Lehman, University, Va., reported an interesting case of the abdominal aorta and vena cava in which both were ligated but death soon followed.

The Use of Heparin in Thrombosis: W. E. Gallie, D. W. G. Murray, and Charles H. Best, Toronto, Ont.—"Heparin was discovered in 1916 and proved to be an antioagulant. Attempts at using it on human beings showed that it was toxic and unsuitable for clinical use. It has now been purified and is obtained in crystalline form with a potency of about 500 units per mg. Experiments were started in 1932, to determine: (1) Toxicity; with the impure form of heparin, toxic symptoms were produced in animals, but as the heparin became purified the toxic symptoms soon disappeared; with the crystalline form in more than 230 clinical cases there have been no toxic effects. (2) The effect of heparin on thrombosis: (a) Experiments were undertaken in which veins were injured by (1) mechanical and (2) chemical means; the efficacy of heparin was studied. (b) In 230 clinical cases where the needle was lying in the lumen of the vein for periods from three days to three weeks, thrombosis did not occur. (c) With end-to-end suture of arterial and venous grafts in arteries, 60 per cent became occluded. Where heparin was given all remained patent as long as injections continued and many for months afterwards. (d) When an embolus was placed in an artery and left for forty-eight hours and then removed, all vessels remained patent, where heparin was given intravenously. (e) In transplantations of the kidney into the neck the circulation was maintained more frequently when the intravenous injection of heparin was employed. Application: heparin has been administered postoperatively to cases where thrombosis in veins and resulting pulmonary embolism was in danger. In 230 cases in which it has been given, there has been no evidence of thrombosis or embolism. In cases of thrombophlebitis, the symptoms were rapidly improved after administration. It is suggested that heparin might be useful in other diseases where thrombosis is a factor."

Heparin is not toxic. It prevents thrombosis and decreases clotting time, but clotting time returns to normal quickly after drug is stopped. Experiments where sections of vein grafted into defect in artery will not clot with heparin and graft lives. Also possibly great good may result after embolectomy to prevent reclothing if heparin is given for two weeks. Also, it is given postoperatively to prevent pulmonary embolism. Thrombophlebitis (28 cases) improved more rapidly with heparin. There are possibilities of great good in coronary thrombosis, sinus thrombosis, etc.

Discussions: Dr. Best said the purification of heparin made it possible for clinical use. H. Lillenthal, New York, N. Y., recommended leeches to prevent thrombosis, and has had good results in thrombophlebitis. F. W. Bancroft, New

York, N. Y., referred to his work with sodium diosulfate in the prevention of post-operative thrombosis. He also thought that high blood protein and fat content was a factor in thrombosis. Mont R. Reid, Cincinnati, Ohio, discussed the use of heparin in experimental surgery.

Spontaneous Rupture of the Epigastric and Internal Mammary Arteries Within the Rectus Muscle: Robert L. Payne, Memphis, Tenn.—“Interest in this condition centers around the apparent rareness of the lesion, together with the comparative difficulty in diagnosis. Rupture of the internal mammary or epigastric artery within the rectus muscle or sheath may be due to direct or indirect forces which are clear cut as a contributing factor. However, many lesions appear spontaneously, though there is some doubt but what indirect trauma may be a factor in every instance. The clinical syndrome is quite typical, but because of its rarity is commonly treated under a doubtful or mistaken diagnosis, and often neglected over a sufficient period of time to permit extensive extravasation into the muscle with accompanying pressure necrosis, infection, and abscess formation due to neglect.” It should be recognized and often operation done early. Discussed by Mont R. Reid, Cincinnati, Ohio, who endorsed the author's views.

A Study of the Lymphatics in Carcinoma of the Rectum: Vernon C. David and R. K. Gilchrist, Chicago, Ill.—“As a result of this study two conclusions have been drawn: (1) That the number of glands involved with carcinoma cannot be determined except by careful preparation and dissection of the specimen. In connection with this we will describe briefly a new technique for the same. (2) The average number of glands examined in specimens of carcinoma of the rectum run between 10 and 25, as reported in the literature. By the methods described we have been isolating between 50 and 60 glands and have found an average involvement in the resected specimens of about 70 per cent as compared with 35 to 45 per cent described usually. Some rather interesting facts about the method of spread have developed from this study. Naturally, this whole subject brings up the question of prognosis based on involvement of glands by carcinoma at the time of operation. If prior statistics have been based on an average involvement of 35 to 45 per cent of glands, then a new viewpoint of the whole subject of prognosis on a basis of gland involvement will have to be taken.” Small tumors may show many infected glands, and vice versa. Squamous cell and growth may spread to pelvic glands.

Dr. David emphasized the important points of the paper. Harvey B. Stone, Baltimore, said presentation shows clearly that extensive resection is necessary to get all infected glands as some are often very high.

The paper was also discussed by R. Colp, New York, N. Y., and E. W. Archibald, Montreal, Que.

The Treatment of Intra-peritoneal Abscess Arising from Appendicitis: Edwin P. Lehman, University, Va., and William H. Parker.—“A study based upon 1,069 cases of acute appendicitis admitted from 1933 to 1937 inclusive. Great care has been directed towards definition of three groups of appendicitis: (1) simple, (2) with abscess, (3) with diffuse peritonitis. No cases are included in the last two groups without actual established peritonitis, whether or not perforation had occurred. The study is directed towards the treatment of Group 2, comprising 181 cases. The factors studied are: (1) mortality, (2) complications, (3) hospital days, (4) fever days, (5) drainage days. Positive conclusions are stated on only those differences in data which can be shown by statistical methods to be significant. The abscess cases are divided into five groups according to the therapeutic proce-

dures carried out. Conservative treatment of appendiceal abscess without operation at any time during the acute phase gives by far the best results if it can be carried out successfully. However, the total result of the method must be judged on a combined group, including both the successfully completed cases under conservative treatment and those in which operation is later forced by unfavorable progress of the disease. Comparison between this combined group and the group in which operation was done as an elective procedure leads to the conclusion that the initiation of conservative treatment in appendiceal abscess is the method of choice."

Discussed by F. A. Collier, Ann Arbor, Mich., who agreed with the conservative treatment advocated. Shelton Horsley, Richmond, Va., preferred prompt operative treatment generally and showed statistics justifying the plan. T. G. Orr, Kansas City, Mo., and Roscoe R. Graham, Toronto, Ont., also waited and treated abscesses without operation. O. H. Wangenstein, Minneapolis, Minn., agreed but warned against prolonged delay when the abscess was large and the patient continued febrile. A. O. Whipple, New York, N. Y., thought that there was danger in leaving the impression that delay or nonoperative treatment was advisable as a general rule because it might lead to late rather than early operation in appendicitis.

Epidermoid Cysts of the Spleen: Albert H. Montgomery, Eugene T. McEnery, and Albert A. Frank, Chicago, Ill.—"Epidermoid cysts of the spleen are usually large, solitary, and lined with stratified pavement epithelium with prominent intercellular bridges. No other epidermal or dermal elements are found. They have been reported as weighing as much as 3 kg. and to have contained 1,500 c.c. of watery chocolate fluid usually containing cholesterol. The general structure is strikingly similar from trabeculated inner surface, to fibrous capsule and secondarily compressed spleen. The splenic tissue is usually unaltered except for gross compression and fibrous replacement adjacent to the cyst capsule. All clinical symptoms may be explained on the basis of compression alone. Epidermoid cysts of the spleen have been considered relatively rare anatomic entities, and few cases have been reported in the literature. No satisfactory explanation of their origin has been offered. With the assumption that epidermoid epithelium is necessarily ectodermal in origin, the necessity arises of accounting for ectoderm in an organ presumably arising from mesenchyme. Various theories of the origin of epidermoid cysts of the spleen will be discussed. Two cases are reported with clinical and pathological findings. The lesion seems to be so rare it is thought worth while to report these two additional cases and perhaps stimulate the report of others by members of the association."

Mediastinitis Following Cervical Suppuration: Herman E. Pearse, Jr., Rochester, N. Y.—"Infection of the neck that invades the cervical spaces may gravitate into the chest and cause a mediastinitis. The pathways of this spread have been studied and an operation to prevent it has been suggested. When suppuration in the mediastinum develops, it may be drained through the neck, which results in recovery of about two-thirds of the patients treated. The management of this type of suppurative mediastinitis is discussed from experience with anatomical dissection and the treatment of clinical cases both personal and those derived from the literature." A study of 110 cases in the literature and 11 cases of Pearse's own were reported; 71 in the retrovisceral space and 21 in the carotid sheath and 8 pretracheal. Drain in the neck in front lateral to esophagus. A 35 per cent mortality.

Discussions: E. D. Churchill, Boston, Mass.: Perforation of esophagus by endoscopy which is fatal unless immediately drained. The posterior approach may

be necessary if infection low in mediastinum. M. B. Tinker, Ithaca, N. Y., and Howard Lilienthal, New York, N. Y., urged early operation. John Alexander, Ann Arbor, Mich., discussed the value of the anterior incision in the early cases and the posterior approach in cases deep in the mediastinum. O. H. Wangenstein, Minneapolis, Minn., suggested the value of x-ray showing air in mediastinum soon after perforation. He also advised posture in drainage.

The Iodine Metabolism in Exophthalmic Goiter: George M. Curtis, Columbus, Ohio.—“The development of suitable micromethods has permitted analysis of the iodine content of the blood, urine, feces, and sweat, as well as the content of the thyroid gland. As a consequence we have investigated the total iodine metabolism of patients with exophthalmic goiter. The blood iodine is greatly increased over normal. The urinary excretion of iodine is increased. There is also an increased loss of iodine, particularly in the feces, and in the sweat. If the intake of iodine in the food, water, and air is accurately determined, it is found that patients with exophthalmic goiter are in a definite increased negative iodine balance. Iodine depletion thus occurs in the usual progress of this disease.” Discussed by Frank H. Lahey, Boston, Mass., who said some patients have low blood iodine with high metabolic rate, which is contrary to the usual.

REVIEW OF THE THIRTY-EIGHTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF PATHOLOGISTS AND BACTERIOLOGISTS, ATLANTIC CITY, N. J., MAY 3 AND 4, 1938

E. T. BELL, M.D., MINNEAPOLIS, MINN.

(From the Department of Pathology, University of Minnesota Medical School)

DALE REX COMAN (by invitation), Morton McCutcheon, and (by invitation) Paul T. DeCamp, Philadelphia, Pa.: **Chemotropism Induced by Streptococcus Hemolyticus in Leucocytes From Normal and Immune Animals.**—Chemotropism was studied on the warm stage. The polymorphonuclear leucocytes moved toward the bacteria at an average speed of 10 to 15 microns per minute. There was no significant difference between the behavior of the leucocytes from immune and nonimmune animals. Antibodies in the serum therefore play no role in chemotropism.

Max M. Strumia, Bryn Mawr, Pa.: **Serologic Studies in Children Before and After Vaccination With the Scarlet Fever Streptococcus Toxin.**—Strumia studied the serologic reactions in children before and after vaccination with scarlet fever streptococcus toxin. He found no significant serologic differences between the Dick negative and the Dick positive stages.

Jerome T. Syverton and **George Packer Berry** (by invitation), Rochester, N. Y.: **Multiple Virus Infection of Individual Host Cells.**—Syverton showed that a single cell could harbor more than one virus. This judgment was based upon the occurrence of inclusion bodies within the cells. A cell may harbor the herpes virus (intracellular inclusion) and the vaccine virus (cytoplasmic inclusion). He also used

the B virus and the myxoma virus. A single cell in some instances harbored three viruses. Tumor cells are readily parasitized by viruses.

Robert J. Parsons and John G. Kidd (by invitation), New York, N. Y.: **Oral Papillomatosis of Domestic Rabbits: A Virus-Induced Disease.**—The authors found a spontaneous papilloma on the under surface of the tongue of domestic rabbits. This occurs in the form of multiple papillomas of benign structure. In 700 domestic rabbits, 16.2 per cent had this form of papilloma. When the skin of the rabbit is tarred, the incidence of spontaneous papilloma on the under surface of the tongue increases to 48 per cent. They found that the papillomas may be transmitted by tattooing the filtrate of the tumors on the under surface of the tongue of the rabbit. Papillomas do not grow in other situations. The growth is different from the Shope papilloma, which does not grow on the under surface of the tongue. Immunologically, this papilloma is also separable from the Shope papilloma.

O. C. Woolpert, F. W. Gallagher, Leona Davis (by invitation), and N. Paul Hudson: **Propagation of the Virus of Human Influenza in the Guinea Pig Fetus.**—It was shown that the guinea pig fetus may be used for the growth of the human strain of the influenza virus. The fetus was inoculated intracranially. The fetal lung may be used for inoculation since it contains the virus.

A. Packehanian (by invitation), Washington, D. C.: **The Prevalence of Infectious Jaundice in the United States as Determined by the Agglutination and Animal Inoculation Tests.**—The author stated that Weil's disease is rather widely distributed in the United States, although he does not think that all cases of infectious jaundice are due to leptospirae. He based this statement upon agglutination tests and animal inoculations. He found that field mice are highly susceptible to the spirochetal infection. He studied several epidemics of infectious jaundice, but he did not make it clear what percentage of cases of epidemic jaundice are Weil's disease.

Dudley A. Irwin, Toronto, Ontario: **The Experimental Prevention of Silicosis by Metallic Aluminum.**—Irwin showed experimentally that the addition of 1 per cent of alum to silica prevents the development of silicosis in animals. The alum apparently prevents silica from going into solution. He indicated that some attempts were being made to mix alum in silica dust for the protection of workmen.

Earl B. McKinley, Washington, D. C.: **The Tuberculin Reaction and Its Significance in Leprosy.**—McKinley believes that the high incidence of positive tuberculin reactions in lepers is due to associated tuberculosis and not to the leprosy itself.

Edgar H. Norris, Minneapolis, Minn.: **The Cytology of the Human Parathyroid Glands.**—Norris demonstrated the various types of cells that occur in the normal parathyroid glands and in parathyroid adenomas. He believes that increased vacuolization of the cytoplasm indicates functional activity.

Robert A. Moore and (by invitation) Allister McLellan, New York, N. Y.: **A Histologic Study of the Effect of the Sex Hormones on the Human Prostate.**—A few patients with hypertrophy of the prostate were treated with testosterone and others were treated with estrin. Neither of these hormones produced any definite effect upon the enlarged prostate.

Paul R. Cannon and (by invitation) E. M. K. Gelling, Chicago, Ill.: **Pathologic Effects of Elixir of Sulfanilamide Poisoning.**—Caunon reported results of post-mortem examination in a child $3\frac{1}{2}$ years of age who had died from the administration of elixir of sulfanilamide. He also reported the findings in a man 64 years of age who died from similar poisoning. The most striking change was an extreme hydropic degeneration of the cells of the convoluted tubules of the kidneys and of the hepatic cells.

Harry S. N. Greene and (by invitation) John A. Saxton, Jr., Princeton, N. J.: **Uterine Adenomas in the Rabbit.**—Greene studied spontaneous adenocarcinomas of the uterus in rabbits. He observed a number of those spontaneous tumors. The animals finally die of metastases. The gross appearances, as well as the microscopic structure, are closely similar to the corresponding tumor in women. He was unsuccessful with primary transplantation experiments except when the tumor was inoculated into the eye. In this situation it grew well and after several such transplants it grew readily in other parts of the body. It was often successfully transplanted to guinea pigs and rats by intraocular inoculation.

Peyton Rous and (by invitation) John G. Kidd, New York, N. Y.: **A Comparison of the Virus-Induced Rabbit Tumors With the Tumors of Unknown Cause Elicited by Tarring.**—Rous studied tar papillomas of the rabbit's ear as well as Shope papillomas. When Shope papilloma virus is infiltrated into the ear, tarring causes enormous growth of papillomas. He believes that all carcinogenic agents prepare the soil for the virus which causes the tumor. He believes that the tarring of the skin prepares the way for the invasion into the cells of the virus of unknown origin.

William H. Feldman and (by invitation) A. H. Baggenstoss, Rochester, Minn.: **The Residual Infectivity of the Primary Complex of Tuberculosis.**—The authors studied old healed primary tuberculous lesions microscopically and by animal inoculation. They found that nearly all of these healed lesions failed to produce tuberculosis in guinea pigs, even though many of them had well-formed tubercles about the periphery of the old scar. They were inclined to believe that these small tubercles about the scar were due to silicosis.

Benjamin J. Clawson, Minneapolis, Minn.: **The Effect of the Primary Pulmonary Focus Upon the Progress of Experimental Pulmonary Tuberculosis.**—Clawson demonstrated that by direct inoculation of B.C.G. into the lungs of rabbits a lesion is produced which resembles the lesion in primary pulmonary tuberculosis except that there is no involvement of the regional lymph nodes. Animals with this pulmonary lesion show a striking resistance to virulent tubercle bacilli.

William E. Ehrich, Philadelphia, Pa.: **The Renal Lesion in Cytotoxic Glomerular Nephritis (in Rabbits).**—Ehrich immunized rabbits with kidney extracts and then injected them intravenously with the corresponding antigen. He produced acute glomerulonephritis and in some instances the lesions progressed to a stage at which it might appropriately be called chronic glomerulonephritis.

REVIEW OF THE THIRTY-FIRST ANNUAL MEETING OF THE
AMERICAN ASSOCIATION FOR CANCER RESEARCH,
ATLANTIC CITY, N. J., MAY 2, 1938

E. T. BELL, M.D., MINNEAPOLIS, MINN.

(From the Department of Pathology, University of Minnesota Medical School)

E. M. BURKE, Buffalo, N. Y.: **Sarcoma of Soft Tissues.**—Burke reported on 201 cases of sarcoma of the soft tissues. There were 107 males and 94 females; 30 per cent of the patients were under 30 years of age. The lower extremities were involved most frequently. The 5-year survivals were as follows: grade 1 sarcoma, 73.2 per cent; grade 2, 42 per cent; grade 3, 14 per cent.

Leonell C. Strong, New Haven, Conn.: **VII. The Liquefaction of Spontaneous Tumors of the Mammary Gland in Mice by Heptyl Aldehyde.**—Strong studied the influence of heptyl aldehyde upon spontaneous tumors of the mammary gland in mice. The drug was given in the diet, about 1 drop to 2 gm. of food. The dosage was adjusted to the weight loss. It was given periodically over a long period. The drug produced liquefaction of the tumors, often with collapse and shrinkage of the tumor mass. The average survival time of the treated animals was 83 days, while that of the controls was 55 days. The tumor finally becomes resistant to the chemical agent and no longer responds. Two treated animals were still alive at 160 days. Microscopically he noted a lymphocytic and polyblastic invasion of the disintegrated tumor. The periphery of the tumor, as well as its central portion, showed the effects of the chemical agent.

S. H. Gray and G. Gruenfeld (by invitation), St. Louis, Mo.: **The Production of Carcinoma and Sarcoma by the Subcutaneous Injection of Benzpyrene.**—Both carcinomas and sarcomas were produced by benzpyrene. The chemical agent was given in 4 per cent solution in lard or as a dry powder in capsule. Tumors were obtained with the dry powder as well as with the lard. They introduced 15 mg. of dry powder subcutaneously. Usually there was ulceration of the skin. Both carcinoma and sarcoma were produced and sometimes both types of malignancy were present in the same growth. The ulcer was at first benign but later became malignant. There were no metastases.

A. G. Ido (by invitation), **R. A. Harvey** (by invitation), **F. W. Bishop** (by invitation), and **S. L. Warren**, Rochester, N. Y.: **A Study of the Capillary Development Around the Tumor Transplant in a Window in the Rabbit's Ear; a Demonstration of One of the Common Methods of Metastasis.**—The investigators transplanted a sarcoma into the subcutaneous tissues of the ear of a rabbit and studied the changes through a transparent window which covered the wound. They presented an excellent motion picture showing the growth of the transplanted tumor and the manner in which metastases are formed. The large capillaries which grew into the tumor showed oscillation of the blood current to-and-fro, and these movements detached some of the tumor cells and carried them into the circulation.

Received for publication, June 3, 1938.

Madge Thurlow Macklin (by invitation), London, Ontario: **Can a Study of Human Cancer Teach Us Anything of Value Concerning Its Inheritance?**—Macklin believes that a great deal can be learned about the hereditary transmission of tumors from human material. She stressed the important influence of age in each type of neoplasm and pointed out that each tumor has its own preferred age incidence. She cited the well-known hereditary transmission of retinoblastomas and the carcinomas in xeroderma pigmentosum. Her data also indicated a strong hereditary influence in carcinoma of the breast. She indicated that each tumor must be studied separately.

G. E. Hall (by invitation) and **W. R. Franks**, Toronto, Ontario: **Acetylcholine and Endogenous Carcinogenesis.**—Tumors were produced by acetylcholine, a substance which is formed normally within the body. They obtained one sarcoma of the femur in a dog and sarcomas were obtained readily in rats. The chemical substance was introduced subcutaneously. The first tumor appeared at the fifth month. This work is of interest in that acetylcholine is of physiologic origin, as is estrin.

J. T. Syverton, **R. A. Harvey** (by invitation), **G. P. Berry**, and **S. L. Warren**, Rochester, N. Y.: **The Inactivation of Papilloma Virus (Shope) by Roentgen Radiation With Some Correlated Observations on Other Viruses and Bacteria.**—The Shope papilloma of the ear of a rabbit is easily destroyed with 3,500 r. The effect is the same whether the radiation is given all in one dose or fractionally. When a suspension of the virus is irradiated, an enormous dosage is required to kill it; 1,000,000 r. is ineffective and 14,000,000 r. is required to inactivate the virus. The investigators, therefore, concluded that radiation affected the cells and not the virus. The Shope papilloma virus is more resistant to radiation than any other virus.

Robert Hebbel (by invitation) and **E. T. Bell**, Minneapolis, Minn.: **Carcinoma-sarcoma.**—A malignant tumor of the thyroid gland was described which formed massive metastases in the lungs. The great majority of the metastases had a structure of giant cell sarcoma, while a few had the structure of adult thyroid gland. Both of these types of tissue were present in the primary tumor. Transitions were found, which suggested that the sarcomatous tissue arose by transformation from epithelium. In the sarcomatous portions large numbers of collagenous fibers were formed by the tumor cells, indicating that, if metaplasia has occurred, it is complete. One conception of carcinosarcoma is a tumor arising from epithelial cells which undergo metaplasia in part, forming cells which have the power to produce collagenous fibers.

Halsey J. Bagg and **Flora Hagopian** (by invitation), New York, N. Y.: **The Functional Activity of the Mammary Gland in the Rat in Relation to Mammary Gland Carcinoma.**—Studies in the Wistar strain of rats showed that rapid breeding and prevention of suckling favors the production of mammary carcinoma.

J. J. Bittner, Bar Harbor, Me.: **Relation of Nursing to the Extrachromosomal Theory of Breast Cancer in Mice.**—Bittner presented further evidence indicating that the mother's milk has more influence than heredity in the development of carcinoma of the mammary gland in mice; 83.6 per cent of adult females of the high cancer strain develop carcinoma of the mammary gland, but the offspring of these high cancer females, when fostered from birth by a female of a low cancer strain, develop only 7.4 per cent of mammary carcinoma. It was shown clearly that the incidence of cancer of the breast in mice can be changed enormously without changing the genetic constitution of the animal.

Albert Claude, New York, N. Y.: **The Physical and Chemical Properties of a Chicken Tumor Agent.**—Claude purified and concentrated the active agent of the Rous sarcoma by centrifugation. The centrifugate was so concentrated that it produced tumors in a solution of 10^{-8} . The concentrated centrifugate showed about 25 per cent of lipoids. The author suggested that the virus is a lipid protein combination.

REPORT ON THE MEETINGS OF THE AMERICAN SOCIETY
FOR BIOLOGICAL CHEMISTS, BALTIMORE, MD.,
MARCH 30—APRIL 2, 1938

MILDRED R. ZIEGLER, PH.D., MINNEAPOLIS, MINN.

AMONG the many papers reported at this meeting, only a few have been selected which are of special interest to surgeons.

Frances L. Haven and his co-workers (University of Rochester) studied phosphorus metabolism in growing and adult white rats, with artificially radioactive phosphorus as a tracer. Data were reported giving the distribution of phosphorus fed as sodium phosphate in bones and teeth, internal organs, muscle, blood, and carcinosarcoma No. 256, as well as in the phospholipids of various organs. They found that a large portion of the phosphorus is rapidly transferred to the bony structure of the animal. The concentration of administered phosphorus rises rapidly in tumor tissue and in its phospholipid fraction, the concentration in tumor tissue a few hours after feeding being of the same order as in the phospholipid of liver and kidney and many times that of muscle.

Arthur Knudson, Stuart Sturges, and W. Ray Bryan (Albany Medical College) verified the observations of Roffo, Beard, and others that irradiation of rats with ultraviolet light over a long period of time produces malignant tumors on the ears, nose, eyes, or other exposed parts. They also carried out studies on the cholesterol content of the skin from the face, back, and abdomen of irradiated rats and determined the cholesterol content of the tumors and the blood of these animals. The total cholesterol content of the skin was increased by irradiation. The tumors from these irradiated animals were also very high in cholesterol and ran somewhat parallel with the cholesterol content of the skin from the face of the irradiated animals. However, the free cholesterol in the tumors averaged about 80 per cent, while the free cholesterol from the skin of the face of irradiated rats was 30 per cent. A few determinations on the blood of irradiated rats showed that the total cholesterol and free cholesterol content on the average was below normal.

In an attempt to elucidate the constitutional structure of the melanins, Mona Spiegel-Adolf (Temple University) studied the optical absorption power of various melanins for short-wave light. She used photosynthetic melanins, tumor melanins, and sepiin. Ultraspectrographic investigations showed distinct quantitative differences between photosynthetic melanins and the genuine melanins.

D. B. Dill, H. T. Edwards, and S. Robinson (Harvard University), in a study of metabolic adjustments, exercise, and age, observed that males from 7 to 76 years of age effectively mobilize carbohydrate to maintain the concentration of

blood sugar near its basal value, regardless of age, in work that raises the level of oxygen consumption about seven-fold. The proportion of carbohydrate utilized in such activity was low in boys and independent of age in men. Possibly the 15-hour fast that preceded the work depleted carbohydrate reserve to a greater extent in the boys than in men, leaving the former with a less adequate supply of carbohydrate when exercise was undertaken. Five minutes after brief, severe exercise, blood sugar and lactic acid were moderately elevated in the boys and in the old men; the greatest increase occurred at the intermediate ages. The ratio of increment in blood sugar to increment in lactic acid was high in young men, low in old men.

R. N. Harger, Steven L. Johnson, and E. G. Bridwell (Indiana University) presented methods for the determination of methanol in blood, spinal fluid, urine, and body tissues.

Fred W. Oberst (United States Public Health Service) gave a simple and rapid method for the determination of morphine in the urine of drug addicts. Concentrations as low as 0.03 mg. in 25 ml. of urine are detectable. Morphine may be determined quantitatively in concentrations ranging from 0.08 to 3.0 mg. per 100 ml. of urine by their colorimetric method.

Wendell H. Griffith (St. Louis University) found that the oral or intraperitoneal administration of 50 to 150 mg. of sodium hippurate in 0.1, 0.15, or 0.31 M solution resulted in a 2 to 4° decrease in the body temperature of 50 to 60 gm. rats. The effect of hippurate was temporary and disappeared within 6 to 8 hours, while that of sodium benzoate was more marked and of longer duration. He believes these changes in body temperature to be suggestive, in view of the recent observation that both of these substances inhibited *in vitro* the oxygen uptake of minced tissue and of tissue slices of the rat.

Harry G. Day, Harold J. Stein, and E. V. McCollum (Johns Hopkins University) reported studies on young rats fed different levels of calcium and phosphorus which showed that calcium does not have a unique function in hemato-poiesis and that excess dietary phosphorus interferes with iron utilization, probably owing to the formation of unabsorbable iron phosphate.

James M. Orten (Wayne University) presented data to show that there is a predictable normal relationship among reticulocytes, erythrocytes, and hemoglobin in rats and that definite deviations therefrom should prove as an index to abnormal hematopoiesis in the rat.

Since it has been shown that nicotinic acid and nicotinic acid amide are active in the cure of black tongue in dogs, D. W. Woolley, F. M. Strong, and Robert J. Madden (University of Wisconsin) investigated the anti-black tongue potency of a large series of various related compounds. Their results indicated extreme specificity of structure necessary for anti-black tongue activity. Substitution of alkyl groups in the ring on either nitrogen or carbon, or on the amide N, rendered the vitamin inactive. Their results indicate that, whereas the dog can oxidize a methyl group on the pyridine ring to a carboxyl, it cannot remove the labile alpha-carboxyl in quinolinic acid by decarboxylation nor can it hydrolyze an N-diethylamide to an acid.

Announcement

Eleventh Congress of the International Society of Surgery, Brussels, Belgium, Sept. 19-22, 1938

The Eleventh Congress of the International Society of Surgery, which, as previously announced, was to have been held in Vienna on Sept. 19 to 22, under the auspices of the German government and the cooperation of the German Surgical Society, has been abruptly cancelled by the authorities and, for reasons not yet explained, has been made impossible in Vienna. Fortunately, the transfer of the Congress from Vienna to Brussels, which was promptly effected early in July by the Executive Bureau of the International Society of Surgery, has proved of great advantage in assuring a greater success of the Congress under the liberal patronage of the Belgian Government and the enthusiastic support of the Belgian profession. *The Congress therefore will be held in Brussels without change of date, on Sept. 19 to 22, 1938.* According to the latest information received from the Secretary-General, Dr. Leopold Mayer, the scientific program will be carried out in Brussels in all its details as previously announced for Vienna. In fact, many of the reports assigned to the eminent specialists who are to open the discussions on the official questions selected for debate have been printed, and others in press will be ready for distribution in advance of the meeting.

The prospects of the elaborate Mediterranean cruise, which had been planned by the Belgian Branch of the French Navigation Company, under the direction of the International Bureau at Brussels, will be carried out in full, differing only from the itinerary originally planned for the Vienna Congress by omitting the stops at Budapest and Vienna, and substituting the return to Brussels by rail via Venice, Milan, and Basel in time to arrive in Brussels on Sept. 17 or 18. The cruise will begin in Marseilles on Sept. 4, on board the French packet, *Le Providence* (15,000 tons), and will continue along the North Mediterranean to the Black Sea, with stops at Naples, Athens, Istanbul (Constantinople), Odessa (Russia), Costanze, and Bucarest (Roumania), to return to Brussels by the inland route in time for the opening of the Congress on Sept. 19.

Ample provision for sightseeing and entertainment has been assured by the appointment of active medical committees in each of the stopping places along the route, besides the assurance of success given by the long touristic experience of the Secretary-General himself, who will personally supervise the management of the cruise in its scientific and touristic aspects. During his absence, the secretarial office in Brussels will be occupied by five subsecretaries, Drs. Neumann, Appelmans, Beckers, Dejardin, and Spehl, who will attend to all the business of the Congress until Dr. Mayer's return.

It is probable that since the transfer of the Congress from Vienna to Brussels, the popularity of the Mediterranean cruise has increased, and that the demand for reservations on shipboard will be in excess of the available space. It is important, therefore, that all the Fellows of the Society, and others who may desire to join the Mediterranean cruise, should apply at once to Dr. Leopold Mayer, Secretary-General, 72 Rue de la Loi, Brussels, or directly to the Belgian office of the Compagnies Francaises de Navigation (29 Boulevard Adolph Max, Brussels).

blood sugar near its basal value, regardless of age, in work that raises the level of oxygen consumption about seven-fold. The proportion of carbohydrate utilized in such activity was low in boys and independent of age in men. Possibly the 15-hour fast that preceded the work depleted carbohydrate reserve to a greater extent in the boys than in men, leaving the former with a less adequate supply of carbohydrate when exercise was undertaken. Five minutes after brief, severe exercise, blood sugar and lactic acid were moderately elevated in the boys and in the old men; the greatest increase occurred at the intermediate ages. The ratio of increment in blood sugar to increment in lactic acid was high in young men, low in old men.

R. N. Harger, Steven L. Johnson, and E. G. Bridwell (Indiana University) presented methods for the determination of methanol in blood, spinal fluid, urine, and body tissues.

Fred W. Oberst (United States Public Health Service) gave a simple and rapid method for the determination of morphine in the urine of drug addicts. Concentrations as low as 0.03 mg. in 25 ml. of urine are detectable. Morphine may be determined quantitatively in concentrations ranging from 0.08 to 3.0 mg. per 100 ml. of urine by their colorimetric method.

Wendell H. Griffith (St. Louis University) found that the oral or intraperitoneal administration of 50 to 150 mg. of sodium hippurate in 0.1, 0.15, or 0.31 M solution resulted in a 2 to 4° decrease in the body temperature of 50 to 60 gm. rats. The effect of hippurate was temporary and disappeared within 6 to 8 hours, while that of sodium benzoate was more marked and of longer duration. He believes these changes in body temperature to be suggestive, in view of the recent observation that both of these substances inhibited in vitro the oxygen uptake of minced tissue and of tissue slices of the rat.

Harry G. Day, Harold J. Stein, and E. V. McCollum (Johns Hopkins University) reported studies on young rats fed different levels of calcium and phosphorus which showed that calcium does not have a unique function in hematopoiesis and that excess dietary phosphorus interferes with iron utilization, probably owing to the formation of unabsorbable iron phosphate.

James M. Orten (Wayne University) presented data to show that there is a predictable normal relationship among reticulocytes, erythrocytes, and hemoglobin in rats and that definite deviations therefrom should prove as an index to abnormal hematopoiesis in the rat.

Since it has been shown that nicotinic acid and nicotinic acid amide are active in the cure of black tongue in dogs, D. W. Woolley, F. M. Strong, and Robert J. Madden (University of Wisconsin) investigated the anti-black tongue potency of a large series of various related compounds. Their results indicated extreme specificity of structure necessary for anti-black tongue activity. Substitution of alkyl groups in the ring on either nitrogen or carbon, or on the amide N, rendered the vitamin inactive. Their results indicate that, whereas the dog can oxidize a methyl group on the pyridine ring to a carboxyl, it cannot remove the labile alpha-carboxyl in quinolinic acid by decarboxylation nor can it hydrolyze an N-diethylamide to an acid.

Book Reviews

Emergency Surgery. By Hamilton Bailey. Third Edition. Cloth. Pp. 852, with 816 illustrations, many in color. Baltimore, 1938, William Wood and Company. \$14.

The author, now well-known to American students of surgery for several practical texts, has succeeded admirably in bringing together within the confines of 852 pages a comprehensive discussion of emergency surgery. The theme of the text is "when to operate, when not to operate, and how to operate under emergency conditions." In the preface to the first edition the author states: "While writing the present volume, I have pictured a patient stricken with an urgent surgical condition and a comparatively isolated surgeon called upon to carry out appropriate treatment." The scope of the present volume would lead one to believe that the author has directed the third edition in part to a more restricted audience. There are conditions, such as heart tamponade, into which it would appear eminently fitting that the "isolated surgeon" should receive as much orientation in recognizing the existence of the emergency as in how to relieve it.

The author writes in an interesting manner. The text is illustrated profusely and well and the references to literature have been chosen with care.

The author fails to point out the shortcomings of the closed method of drainage in empyema. There are too many already who believe that the application of suction to a catheter in the thorax affords perfect drainage of the free exudate without irrigation of fluid or the admission of air to the pleural pocket. The author implies that he secures continuous gastric aspiration by employment of a syringe, a method which, in this country at least, never attained any vogue. The author, too, probably will find that a water siphon is far superior for the evacuation of gas and fluid from the gastrointestinal canal. The author also endorses cecostomy as the operation of choice in acute obstructions of the colon, an operation which surgeons cannot perform in the presence of great distention and still maintain a respectable mortality. The author clings still to the idea that sudden decompression of the urinary bladder per se is hazardous. He appears to favor early ligation of the angular vein as a preventive measure in carbuncle of the face.

There is much to praise in this splendid volume and little to criticize. The experienced surgeon will find helpful suggestions in it and to the general practitioner and occasional surgeon it will be a useful guide.

The Biology of Arteriosclerosis. By M. C. Winternitz, R. M. Thomas, and P. M. LeCompte. Cloth. Pp. 112, with 116 illustrations and 59 in color. Springfield, Ill., 1938, Charles C. Thomas. \$1.

This important monograph deals with the morphology of arteriosclerosis. The authors skip over quite lightly the rôle of cholesterol and its esters in the production of arteriosclerosis. It is their contention that the vasa vasorum play an all important rôle in the origins of arteriosclerosis, and that inflammatory processes and

At the present time the American Committee has given authority to the American Express Company to set up group travel direct to Brussels as well as to outline several trips which will bring the Fellows to Marseilles by Sept. 4, where, as it is described above, the French packet, *Le Providence*, will start on its Mediterranean cruise to the Black Sea.

Membership in the International Society and the Congress alone will entitle one to reduced rates and privileges over practically all the European railways and other means of transportation, on presentation of the certificate or card of membership. All the procedures required to secure reduction of fares and other privileges in the different European countries are fully detailed in the circulars recently issued to all the Fellows of the Society by the Secretary-General, the Belgian Touristic Agency of the French Navigation Companies, at 29 Boulevard Adolph Max, Brussels, and by the American Express Company.

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hemorrhages in the vessel wall are the likely precursors of sclerosis of arteries. Evidence is offered by the authors which indicates that the occurrence of hemorrhago or other exudation into the interior may lead to thrombus formation upon the intimal surface with occlusion of the lumen. Mural arteries to blood vessels have been traced by the authors from three sources: (1) the adventitia, (2) the lumina of arterial branches, and (3) directly from the intimal surface of the arterial wall.

It is the expressed hope of the authors that a better understanding of the physiologic and pathologic occurrences in the arterial wall will bring arteriosclerosis out of the "limbo of degenerations into the fold of processes based on the understanding that exists for other biological phenomena."

The authors have employed histologic sections of cleared materials after intravascular injections as the basis of their study. The text is illustrated profusely and a large number of the reproductions are in natural color. This is a splendid little monograph which deserves to be studied carefully by everyone interested in the subject.

The Diary of a Surgeon in the Year 1751-1752. By John Knyveton. Edited by Ernest Gray. Cloth. Pp. 322, with 9 illustrations. New York, 1937, D. Appleton-Century Company. \$2.50.

This journal kept by a young surgeon deals with his training in a London hospital and a sea voyage as surgeon's mate almost two hundred years ago. Those were stirring times and the journal is exciting in its interest. Anatomy was the basis of training for a surgeon. Operations were those of necessity and were in every sense of the word severe ordeals for all participants. The hope and despair of patients and surgeons are related with a sympathetic understanding which needs no explanation to a twentieth century audience. Generous bleeding and a free "scouring of the bowels" were the therapeutic measures directed at the feverish state attending the sequelae of operations. It seems not a little strange to us that cleanliness was so little appreciated.

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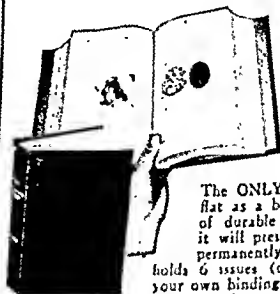
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